CMG-5TD

DIGITAL ACCELEROGRAPH SYSTEM

USER'S GUIDE

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1. HOW THIS USER'S GUIDE IS ORGANISED

This user's guide is organised in sections with each section dealing with a specific topic.

Generally speaking, background material and technical explanations are found in the later sections, while practical instruction occurs at the beginning. A list of tables and specifications are found at the end of the manual.

Each section of the user's guide is kept, as nearly as possible, self-contained and free-standing so that the sections can be read in any order. General cross-references are provided where necessary, but complicated notation of the sections and paragraphs is avoided.

A very brief description of the user guides sections are given below. The contents page provides the titles of each sub-section.

INTRODUCTION: This section summarises the CMG-5TD system design, use and application.

QUICK START: This section gives quick itemised procedures for unpacking, installing and operating the CMG-5TD. **The user can use this section to quickly deploy the instrument and operate the system.**

OPERATION: This section gives detailed instructions to operate the CMG-5TD accelerograph system.

ACC. DESC.: This section describes the accerelometer section of the CMG-5TD.

DIGITIZER DESC: This section describes the digitizer section of the CMG-5TD.

COMMS - UPS: This section describes the Communications-UPS Breakout Box.

TEST DATA: This section describes the factory-provided test data, and gives basic guidelines for interpreting and using them.

PINOUTS: This section gives pinouts for the CMG-5TD and the Communications-UPS Breakout Box.

SPECIFICATIONS: This section lists the CMG-5TD system specifications.

2. INTRODUCTION

The CMG-5TD Accelerograph System consists of 4 components: a digital-output accelerometer (CMG-5TD), a GPS receiver (GPS-3), a Communications/Uninterruptable Power Supply Box (2 models: serial server and serial modem), and data acquisition software (for Windows, LINUX and SOLARIS platforms). The system design philosophy is to provide maximum flexibility to the user, both at the present time, and in the future, as new data storage and communications technologies become available.

The CMG-5TD consists of a fully-integrated triaxial accelerometer (CMG-5T) and a matched 24-bit digitizer (DM-24) contained in a single, watertight package. It is compact, lightweight, and simple to deploy. It can resolve the full range of acceleration due to microearthquakes (0.1 uG resolution) up to strong local earthquakes (4 g resolution). The CMG-5TD is simple to deploy. The combination baseplate/mounting plate is separable and re-attachable, allowing for quick installation/removal and sensor site re-occupation if necessary. The DC offsets are available at the analog output connector of the CMG-5TD, and are user-accessible and adjustable

via adjusting screws on the top cap of the instrument. The GPS-3 receiver is attached to the CMG-5TD via a 20m (standard; other lengths up to 50m are available) cable.

The CMG-5TD is connected to the Communications-UPS Box by a 25m power/data cable. Because the Communications-UPS Box is a separate unit, it need not be located at the CMG-5TD. Instead, it can be located up to 25m from the CMG-5TD, at a location providing mains power and a communications port (TCP/IP or phone line). If additional separation of the CMG-5TD and the Communications-UPS Box is required, the 25m cable may be replaced by any RS-232-compatible communications link (short haul modem, spread-spectrum transceiver, etc.), as long as power for the CMG-5TD is available at the sensor site. CMG-5TD digital output and configuration can be monitored and adjusted locally at the Communications-UPS Box using a portable computer or a PALM digital assistant. The Communications-UPS Breakout Box includes an Uninterruptible Power Supply for the CMG-5TD system, with an automatic 4-hour battery back-up in the event of mains power failure.

The Communications-UPS Box (Serial Server version shown above) can be connected to a central data acquisition center via a serial link(s), network (using TCP/IP), or phone line (using modems). The central-site data acquisition software runs on a Windows PC (SCREAM), a LINUX PC (SCREAM), or a SOLARIS workstation (GCFUNIX). These programs can communicate directly with popular data analysis programs such as Earthworm, Antelope, and Seisan using the appropriate software module.

3.0 QUICK START

3.1 UNPACKING AND PACKING

The CMG-5TD accelerometer system is delivered in a single cardboard box with foam rubber lining. The packaging is specifically designed for the CMG-5T system. Whenever transported, the CMG-5TD system should be packed in its original shipping container. The packaging should be saved for re-use in the event of a later shipment.

Upon receipt of the equipment, please note any damage to the package. Unpack on a clean surface. The package should contain: digital accelerograph, a separable leveling baseplate, baseplate screws, concrete anchor and mounting bolt, GPS receiver, GPS receiver cable, power/data connection cable, communications-UPS breakout box, and mains power cord.

Place the CMG-5TD on a table and identify:

1. The power/data cable connector on the CMG-5TD top cap.
2. The GPS cable connector on the CMG-5TD top cap.
3. The analog connector on the CMG-5TD top cap.
4. The north orientation symbol on the CMG-5TD handle.
5. The bubble level on the CMG-5TD top cap
6. The screw on/off cover for output offset adjustment on the CMG-5TD top cap.
7. The serial number on the top of the CMG-5TD top cap.

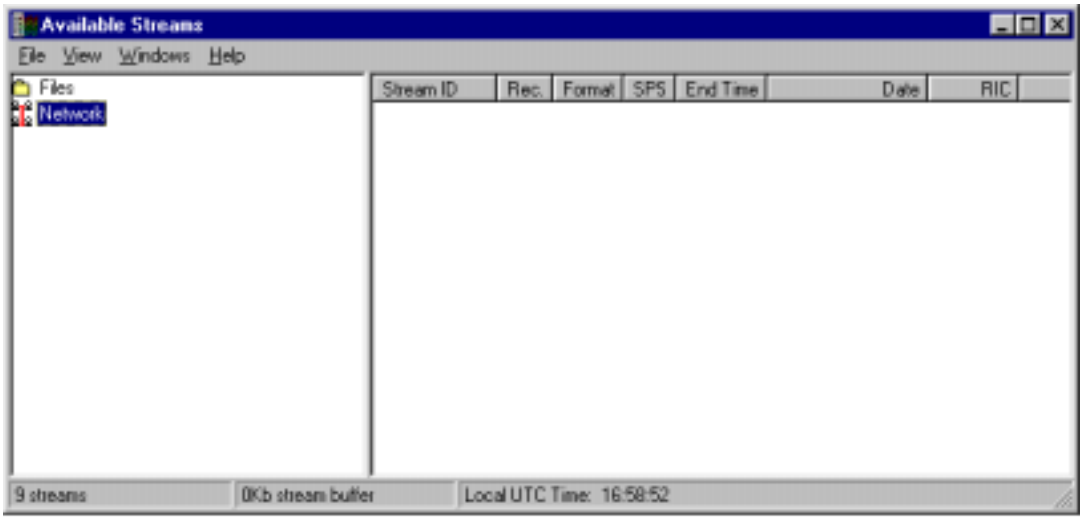
3.2 INITIAL CHECK-OUT

This section gives a quick outline for initial system test which should performed prior to installation. You must provide mains power supply (110 to 220 VAC) and a PC (running SCREAM) or a PALM digital assistant (running SHOUT).

Attach the leveling baseplate to the base of the CMG-5TD using the screws provided. Set the CMG-5TD onto a flat surface. Using the large hex screws on the baseplate in conjunction with

the bubble level, level the instrument. Connect the CMG-5TD to the Communications-UPS Box using the power/data cable. Connect the Communications-UPS Box to the PC or PALM using a standard serial cable. Switch on the power supply. Using the PC, (see separate SHOUT instructions if using PALM) start SCREAM and take the following steps:

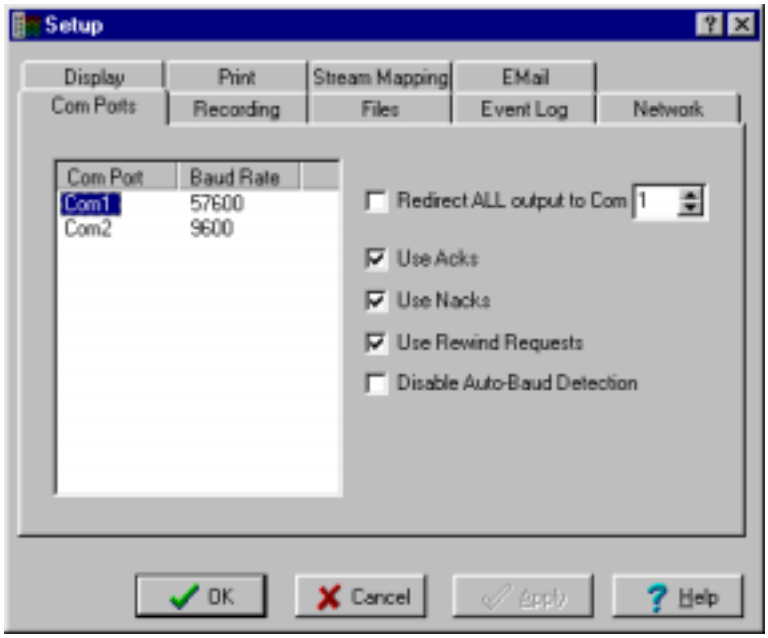
1. To configure the COM port connected to the digitiser, start from the main window in **SCREAM**:-



2. Click on the '**File**' button , select '**Setup**'

3. Select the '**Com Ports**' tab

4. Click on the COM port to which the Digitiser is connected.



5. The factory-set baud rate for the CMG-5TD is 19200. Select 19200 from the list.
6. Click on the **'OK'** button to return to the main **Available Streams** window.

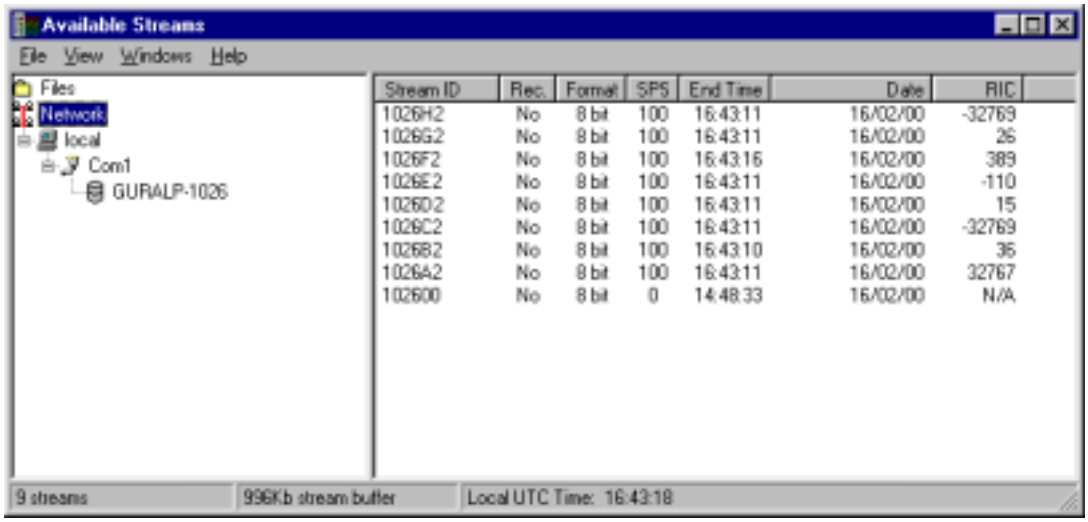
7. In the **Available Streams** window the identifier of the digitiser will appear in the left hand frame (which appears similar to the tree type format of Windows Explorer) under:-

Network >

Local >

Com1' (if Com1 is used)

8. The data streams will appear in the right-hand frame.



9. The **Stream ID's** are six character strings uniquely identifying each instrument, component and sample rate. (There may be up-to four different sample rates per channel)

The stream ending in '00' contains status information from the digitiser.

Depending upon the selected sample rate, then the streams with the higher sample rates will appear in the display sooner than the slower sample rates.

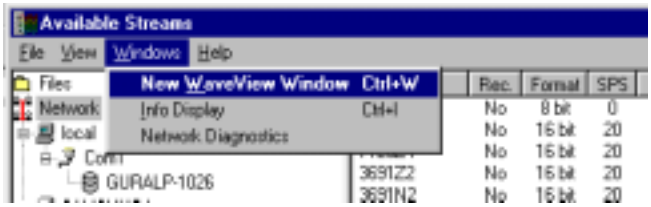
10. If a digitiser module is running then the format will most likely be 16 or 32 bit format as indicated in the **Available Streams** window, due to the seismic data.

11. If a Stand-Alone digitiser is running, then an analogue seismic instrument can now be connected to a **Sensor Input** port.

12. From the main '**Available Streams'** window,

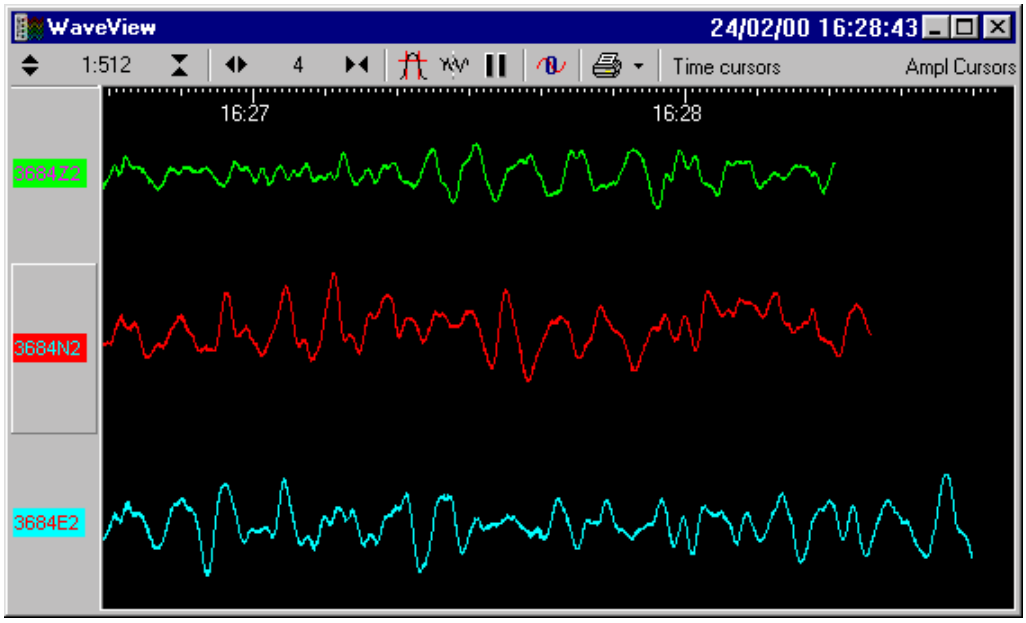
click on the '**Windows**' button,

choose **'New WaveView Window**' to create a WaveView window for displaying the data.



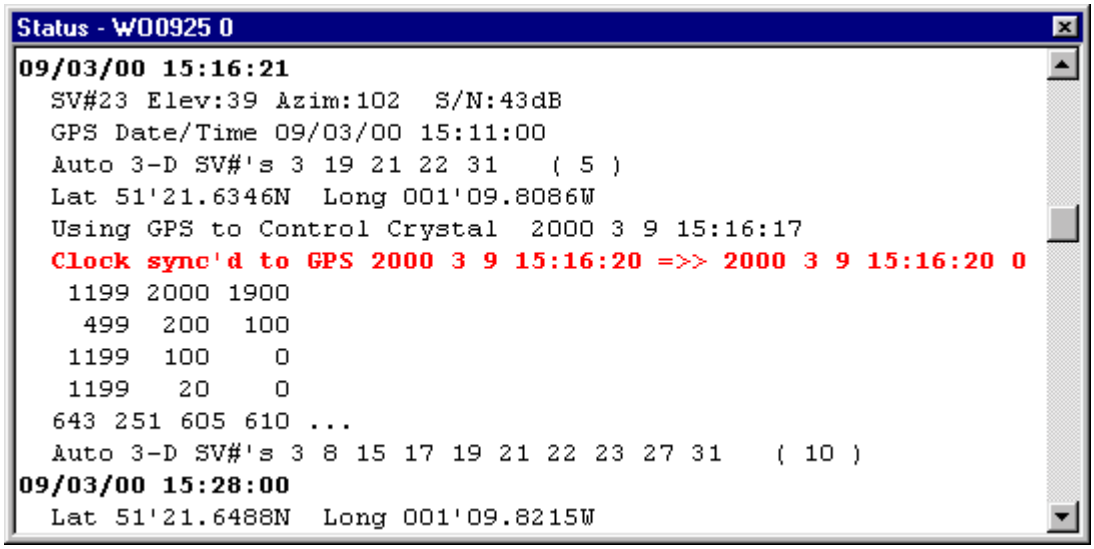
13. Select the data streams in the right side of the window and drag them into a '**Waveview**' window.

14. **SCREAM** will now display digitised data in the '**Waveview**' window.



Above is shown a basic **WaveView** window showing one 3 component instrument.

15. To see status information coming from the digitiser, right click on the status stream, from the pop-up menu select '**View**'. A new window, '**Status**' should open containing text. The first blocks will give the boot message from the DM, including its software revision and the data streams selected for down-loading and triggering. Later blocks give information on the expected GPS satellites, the location of the GPS antenna, time synchronization status and transmit and receive baud rates for each channel and the data link.



While viewing the time series from all three components in a WaveView window, gently tap the CMG-5TD, and observe the response of all three components. If the CMG-5TD passes this initial basic test, then you may proceed to install the system (see the Operation section of this User's Guide).

4.0 OPERATION

4.1 INSTALLATION OVERVIEW

The following steps make up the installation procedure. Detailed instructions follow in section 4.2.

Unpack the accelerograph system from the reusable container (See quick start). Save the shipping box for possible future use.

Prepare the mounting surface.

Mount the leveling baseplate to the CMG-5TD.

Orient the CMG-5TD using the orientation pointers.

Anchor the baseplate to the mounting surface.

Level the CMG-5TD.

Install the GPS receiver providing a clear view of the sky, and connect it to the CMG-5TD using the GPS cable.

Connect the CMG-5TD to the Communications-UPS Box using the power/data cable.

Connect the Communications-UPS Box to mains power and to a PC (running SCREAM) or a PALM (running SHOUT).

Switch on the power and view the acceleration time series using SCREAM or SHOUT.

Using a DVM, check and adjust the CMG-5TD offsets if required.

Cover the sensor with a polystyrene cover for long term thermal stability. The cover will act as a thermal shield from draughts. Position the polystyrene box carefully so that it does not touch the sensor package.

Connect an ethernet cable (TCP/IP), phone line (modem), or serial cable to the Communications-UPS Box.

4.2 INSTALLATION METHODS

The surface should have a scribed north/south orientation line accurately surveyed from reliable markers. Mount the concrete anchor into the mounting bench, about the middle of the orientation line. Loosely attach the mounting (lower) portion of the leveling plate to the concrete

anchor, using the bolt provided. Attach the upper portion of the leveling plate to the base of the CMG-5TD using the screws provided. Finally, attach the CMG-5TD to the mounting base by joining the two portions of the leveling plate using the socket-cap screws provided.

4.3 CMG-5TD ORIENTATION

Use the handle and north indicator inscribed in the handle to orient the CMG-5TD.

4.4 CMG-5TD LEVELING

Use the large socket-cap screws to level the CMG-5TD. Remove the upper portion of the mounting plate, then tighten down the concrete bolt, securing the base. Then re-attach the upper portion of the mounting plate, with the CMG-5TD. Check orientation and level, then tighten down the leveling locking nuts.

4.5 POWER SUPPLY CONSIDERATIONS

The system is designed to operate from a mains power supply (110 to 220 VAC). Alternatively, the system can be operated from a +12 to +24 VDC supply.

4.6 CMG-5TD CONNECTIONS

Connect the GPS receiver and the Communications-UPS Box to the CMG-5TD using the cables provided.

4.7 DATA ACQUISITION

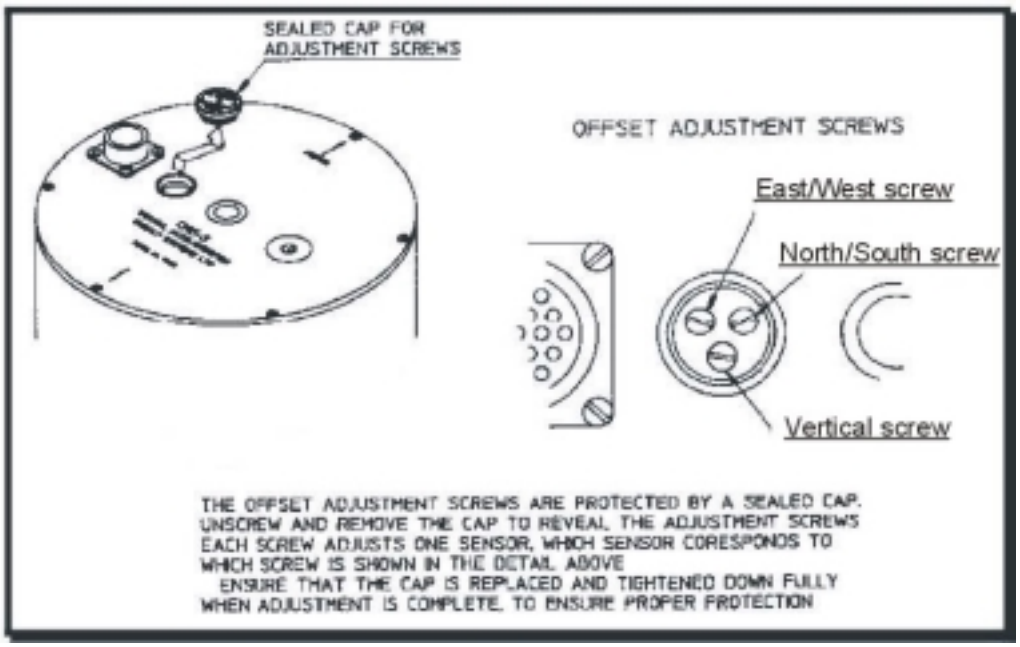
Turn on system power, and acquire serial data at the Communications-UPS Box using SCREAM (PC) or SHOUT (PALM). To acquire data TCP/IP data using the serial server, add the server's IP address to the server section of SCREAM's Network control window. Connect directly to the server using a crossed ethernet cable, or connect via a hub or network. Right-click on the server, and chose connect to acquire data (and disconnect when completed). Detailed data acquisition and system configuration management procedures are given in section 4.9 and in the digitizer section of this User's Guide.

4.8 CMG-5TD OFFSET ADJUSTMENT

When the instrument is installed in it's final position and correctly aligned, the approximate level should be checked using the bubble level on the top of the casing. The bubble should lie completely within the scribed ring. To check the DC offsets, read the RIC value for each

acceleration stream in the SCREAM window. No adjustment is necessary if these values are less than or equal to +/- 5000 counts.

To adjust the DC offsets, remove the screwed cover protecting the adjustment screws, as shown in the diagram below.


SEALED CAP FOR ADJUSTMENT SCREWS
OFFSET ADJUSTMENT SCREWS
East/West screw
North/South screw
Vertical screw
THE OFFSET ADJUSTMENT SCREWS ARE PROTECTED BY A SEALED CAP. UNSCREW AND REMOVE THE CAP TO REVEAL THE ADJUSTMENT SCREWS EACH SCREW ADJUSTS ONE SENSOR, WHICH SENSOR CORESPONDS TO WHICH SCREW IS SHOWN IN THE DETAIL ABOVE
ENSURE THAT THE CAP IS REPLACED AND TIGHTENED DOWN FULLY WHEN ADJUSTMENT IS COMPLETE, TO ENSURE PROPER PROTECTION

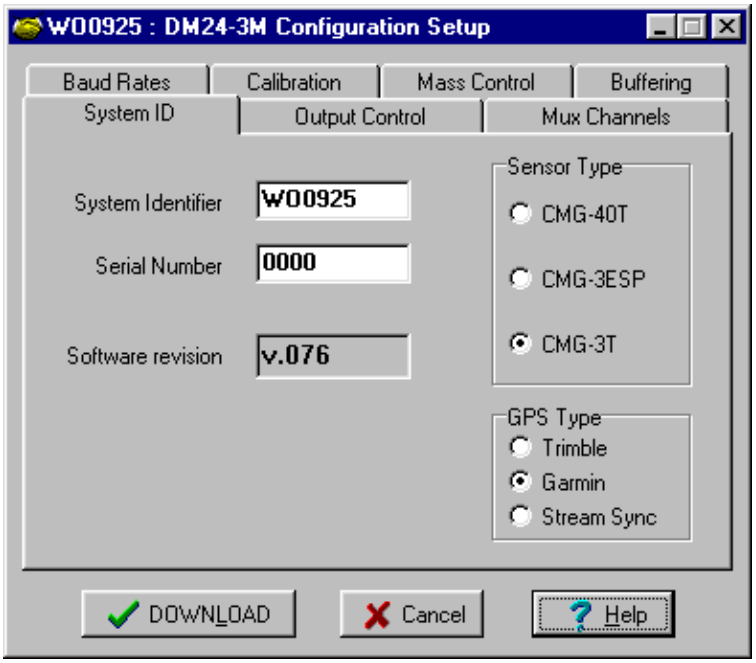
Selecting the channels in turn, adjust the level screws to reduce the RIC values to less than +/- 5000 counts, repeating until consistent results are obtained on all three channels. When offset adjustment is complete, replace the protective cover firmly.

It is likely that after the cover is installed the accelerometer outputs will drift until the system establishes temperature equilibrium with it's environment and the sensor settles down in it's position. If required the offset adjustment can be repeated to achieve a better output offset. With experience, it should be possible to reduce low acceleration output levels, about ± 5000 counts or less.

4.9 DIGITAL CONFIGURATION AND CONTROL USING SCREAM

The CMG-5TD may be reprogrammed using the **SCREAM** configuration setup interface. For any given digitiser, this interface module may be accessed by double-clicking with the left mouse button on the digitiser's icon in the **Available Streams** window. If you single-click on the digitisers icon with the right mouse button, you must select **Configure** from the pop-up menu. Using this module of **SCREAM**, you may interactively set the digitisers system characteristics, control the output of streams at different digitisation rates, and set output baud rates and digitiser buffering parameters.

Using any standard terminal program such as H*yperterm* or *Kermit*, these parameters may also



be changed by sending text commands to the digitiser. This mode may also be invoked from **SCREAM** by single-clicking on the digitisers icon with the right mouse button and selecting **Terminal** from the pop-up menu. When using standard terminal programs, you must initiate command mode by typing **Control-S** when in the text mode. This is done automatically by **SCREAM** when a terminal window is opened to a digitiser. If you use the **SCREAM** configuration set-up interface, data collection will continue while you are setting digitiser parameters. If you use **SCREAM**'s terminal mode or another standard terminal program, data collection will be interrupted until you exit terminal mode by issuing a re-boot command.

Parameters from most of the commands are stored to the battery-backed CMOS and only take effect when the digitiser is rebooted. When you click the **Download** button from the digitiser configuration set-up interface, the parameters you have chosen are transferred to the digitiser and it is automatically rebooted. You will notice a data gap in the **Waveview window** corresponding to the digitiser you have rebooted. This occurs because the reboot automatically clears the data buffer and resets the output block counter.

To access the digitiser configuration setup from **SCREAM,** double-click with the left mouse button on the digitisers icon in the **Available Streams** window (**NOT** the **Local** or **COM** port icons). Alternatively, you can single-click on the digitisers icon with the right mouse button, then select **Configure** from the pop-up menu.

DIGITIZER CONFIGURATION SETUP

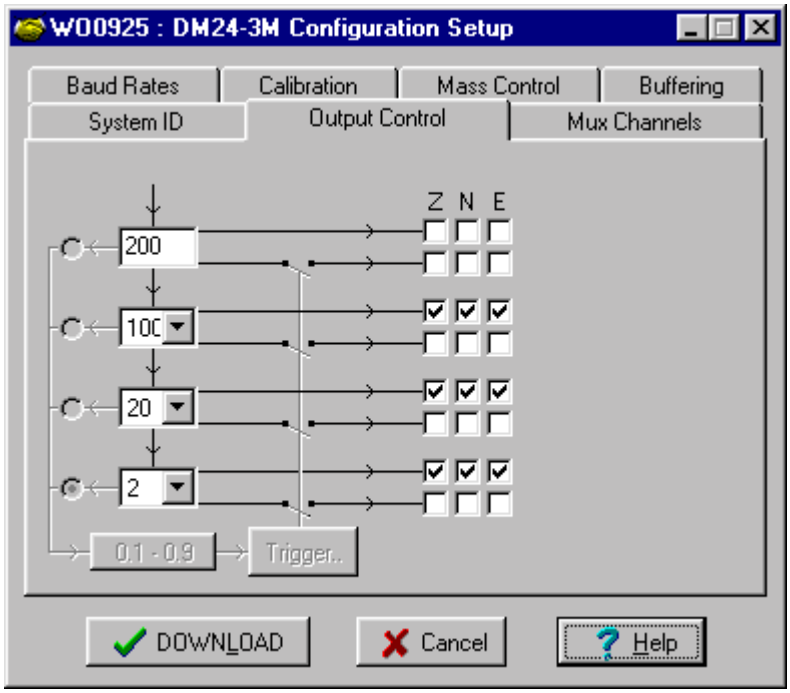
System Identifier and Serial Number: The digitiser type is identified by its system identifier and serial number. These two parameters are stored as the first two 32-bit fields in the header of each data and status block generated by the digitiser to indicate the blocks origin. Each of these parameters consists of 6 alphanumerics encoded as base 36 numbers. On delivery from the factory, the system identifier and the serial number are, respectively, set to the GSL works order number and the DM serial number, or if bonded to a seismometer, the seismometer's serial number. The **System-ID** can be reset to any convenient combination of letters and numbers, such as an abbreviation of your institution.

Sensor Type: This field will be pre-programmed at the factory for the proper sensor type (CMG-5T).

GPS Type: The digitiser can utilize time signals from different sources. Options available from GSL are NMEA (Garmin or Trimble) GPS receivers or stream synchronization. In stream synchronization, time signals from a GPS antenna are sent via telemetry from a central site to the digitiser. In order to synchronize with the time standard, the correct option must be selected.

DIGITIZER OUTPUT CONTROL PROGRAMMING

The screen shot below shows the **Output Control** window for a CMG-DM24-S3 standalone digitiser. The digitiser module set-up will appear the same. The CMG-DM24-S6 will display an extra 3 columns (Z, N and E) on the right –hand side, corresponding to the extra three channels available on that model.



Sampling rate: The output of the digitiser's analogue-to-digital converters (ADC) is data sampled at 2000 Hz. These data are filtered and reduced to lower rates using a digital signal processor (DSP). The DSP has 4 cascaded filter/decimation stages each of which can be programmed for decimation factors of 2, 4, 5, 8 or 10. The output of each stage is called a "tap". The first filter stage, tap 0, is preset to reduce the data by a factor of 10 to 200 samples/second, but each of the subsequent stages may be configured for a different decimation factor.

The four windows on the left of the **Output Control** screen (shown above) allow you to select the sampling rates for three of the four digitiser taps. The upper window corresponds to tap 0 and has a fixed sampling rate of 200 Hz. Each of the other taps may have a sampling rate lower than its predecessor above, if the rate can be achieved by decimation by 2, 4, 5, 8 or 10. Clicking on the window shows a list of the rates that are permitted, given the sampling rate in the window above it.

If some of the outputs are not required then leave the buttons 'unticked' to save communications capacity.

Stream selection: The digitiser has three channels or *streams.* These are depicted by the three columns of small windows labelled Z, N and E in the **Output Control** window shown above.

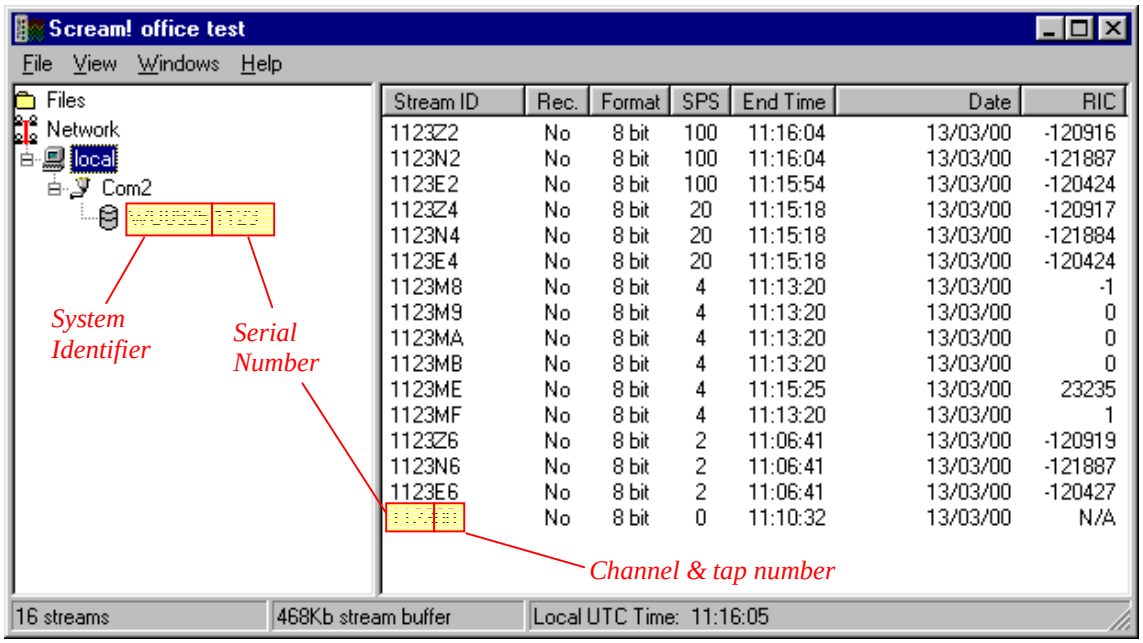
A tick in a box will give an output for the corresponding channel (column) at the corresponding sample rate (row). For each sample rate there are two possible rows to tick. The upper row for each sample rate will give a continuous output at that sample rate; the lower

row, shown diagrammatically as passing through a switch, will only output data when its trigger criteria are met (see below).

The **Stream IDs** displayed in the main **Available Streams** window has six-character ID's. The first four characters identify the digitiser, the last two characters identify the stream from the digitiser. The first of these two characters identify the channel, the second defines the 'tap', or digitiser output (see Data Transmission Protocol & Data Block Structure later).

For example; for the **Output Control** configuration shown above, at the beginning of this sub-section, there will be three data streams, Z, N and E, outputing data at 100sps, 20sps and 2sps. This is shown below, where the digitiser '1123' has the following streams:-

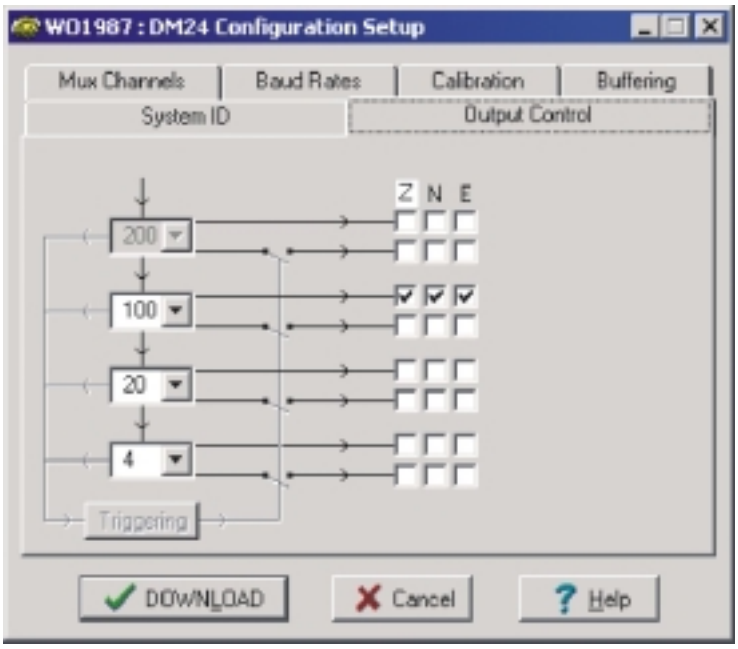
- Z2, N2, E2 are input channels Z, N, E output through the second tap '2';
- Z4, N4, E4 are input channels Z, N, E output through the third tap '4',
- Z6, N6, E6 are input channels Z, N, E output through the fourth tap '6',
- 00 is the digitiser status stream (notice no sample rate)



Stream ID	Rec.	Format	SPS	End Time	Date	RIC
1123Z2	No	8 bit	100	11:16:04	13/03/00	-120916
1123N2	No	8 bit	100	11:16:04	13/03/00	-121887
1123E2	No	8 bit	100	11:15:54	13/03/00	-120424
1123Z4	No	8 bit	20	11:15:18	13/03/00	-120917
1123N4	No	8 bit	20	11:15:18	13/03/00	-121884
1123E4	No	8 bit	20	11:15:18	13/03/00	-120424
1123M8	No	8 bit	4	11:13:20	13/03/00	-1
1123M9	No	8 bit	4	11:13:20	13/03/00	0
1123MA	No	8 bit	4	11:13:20	13/03/00	0
1123MB	No	8 bit	4	11:13:20	13/03/00	0
1123ME	No	8 bit	4	11:15:25	13/03/00	23235
1123MF	No	8 bit	4	11:13:20	13/03/00	1
1123Z6	No	8 bit	2	11:06:41	13/03/00	-120919
1123N6	No	8 bit	2	11:06:41	13/03/00	-121887
1123E6	No	8 bit	2	11:06:41	13/03/00	-120427
[redacted]	No	8 bit	0	11:10:32	13/03/00	N/A

PROGRAMMING TRIGGER PARAMETERS

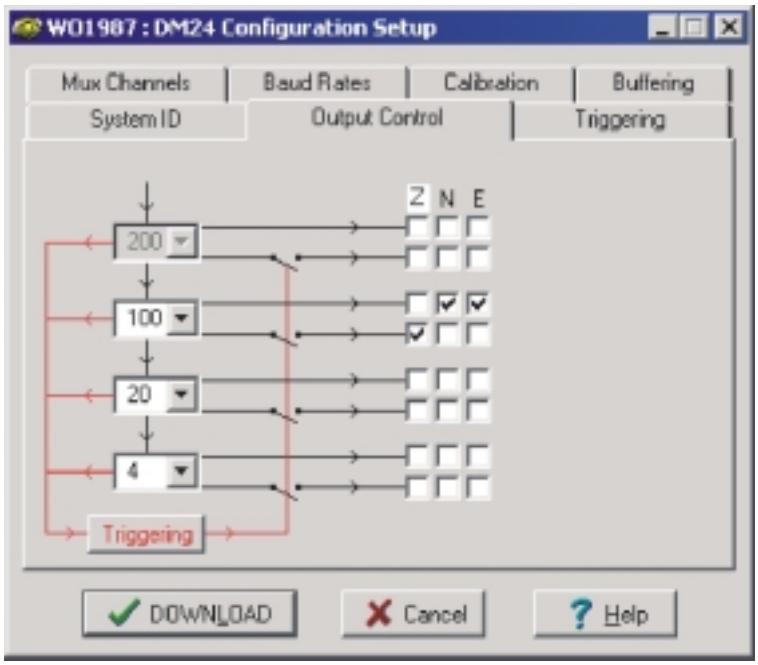
Select the Output Control tab of the Configuration Setup page.



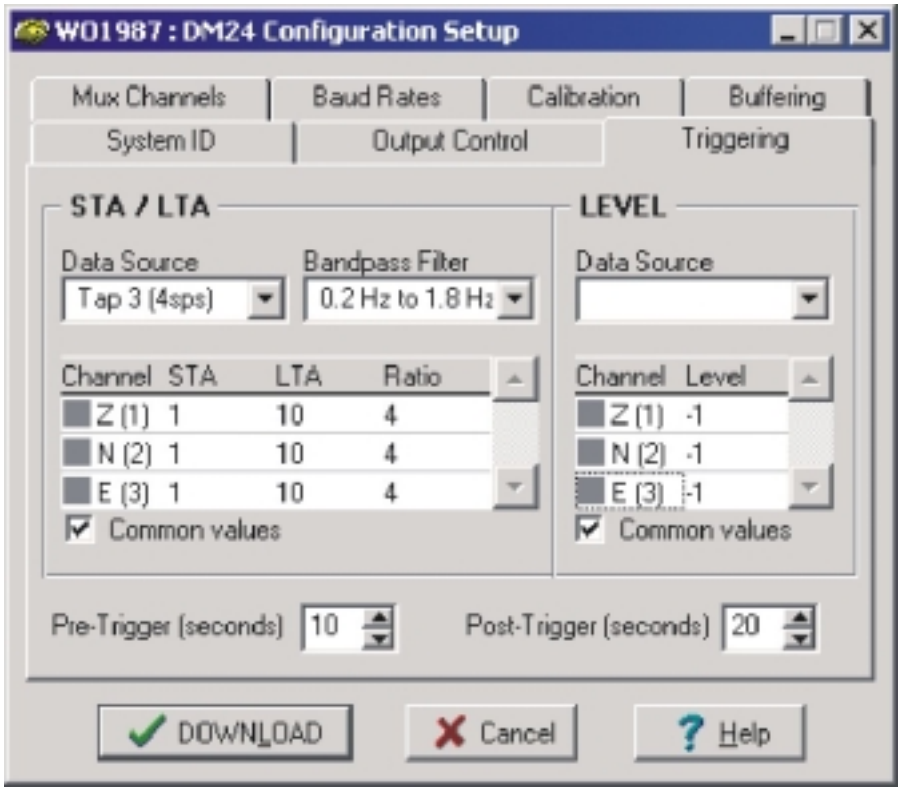
Triggered output stream selection: For each tap there are two rows of boxes where the user can tick either triggered or continuous data outputs. The digitiser applies a simple short term average (STA) - long term average (LTA) algorithm and/or an absolute level (counts) algorithm to a selected stream or set of streams to determine whether the trigger condition is met. These streams may be bandpass filtered before evaluation using standard bandpass parameters. The data transmitted due to the trigger may be from different streams than those used to determine the trigger.

For this to function properly, triggering streams must be selected and trigger criteria must be set by clicking on the **Trigger** button. When at least one stream is selected for triggered output, selection of triggering streams and trigger criteria are enabled. It is possible to trigger off of one tap but record data from one or several different taps.

Triggering streams selection: The triggering tap is selected by marking the circle next to the tap. This tap need not be the tap from which streams are transmitted when a trigger occurs.



Once at least one box is checked for triggered output, the Triggering box and tab are activated. If you set triggering, you must also set the parameters for the trigger criteria.



The Data Source button selects the tap (streams) that will be evaluated for triggers for both the STA/LTA and the Level triggers.

In general, it is not advisable to use an STA/LTA trigger directly from broadband data. The Bandpass Filter button allows the user to select from a set of standard bandpass filters from a pull-down menu (a full list of options is given later in the STA/LTA chapter). The chosen filter will be applied to the streams from the triggering components before they are tested for the trigger condition. The corner frequencies of the pass band of the filter are determined by the Nyquist frequency, which is given by the sampling rate of the triggering data. The three filter options have pass bands between 10 % and 90 %, between 20 % and 90 % and between 50% and 90% of the data's Nyquist frequency, respectively.

Trigger criteria: Trigger criteria for the STA/LTA and Level triggers function may be set in the **Trigger Setup** window, accessed by clicking on the **Trigger** button near the bottom of the **Output Control** window.

The three tick boxes down the left side of the windows (Z, N, E) allows the user to choose the channels (for the specified tap) which will be tested for a trigger condition.

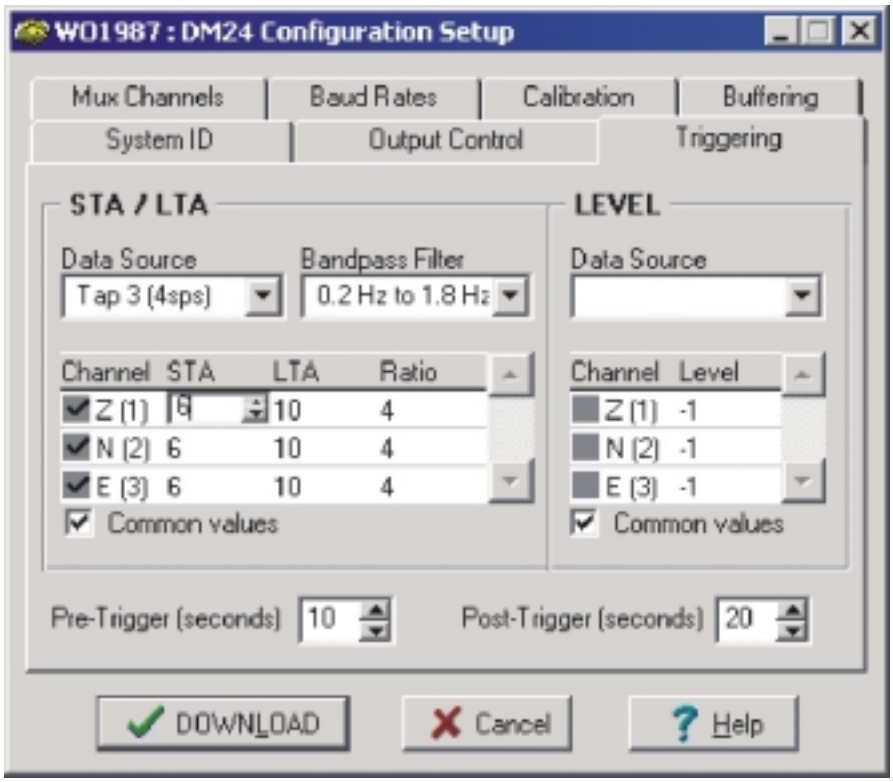
STA/LTA parameters:

The user sets the parameters by clicking on them. Typically, the time interval for the short term average should be about as long as the signals you want to trigger on, while the long term average should be taken over a much longer interval. Both the STA and LTA values are recalculated continually, even during a trigger.

The STA/LTA will constitute a trigger for each of the components selected for triggering. The system declares a trigger when any one of the triggering components exceeds this value. The trigger ratio is continuously recalculated for all components and the system will detrigger when all the components selected for triggering have fallen below their respective ratio values.

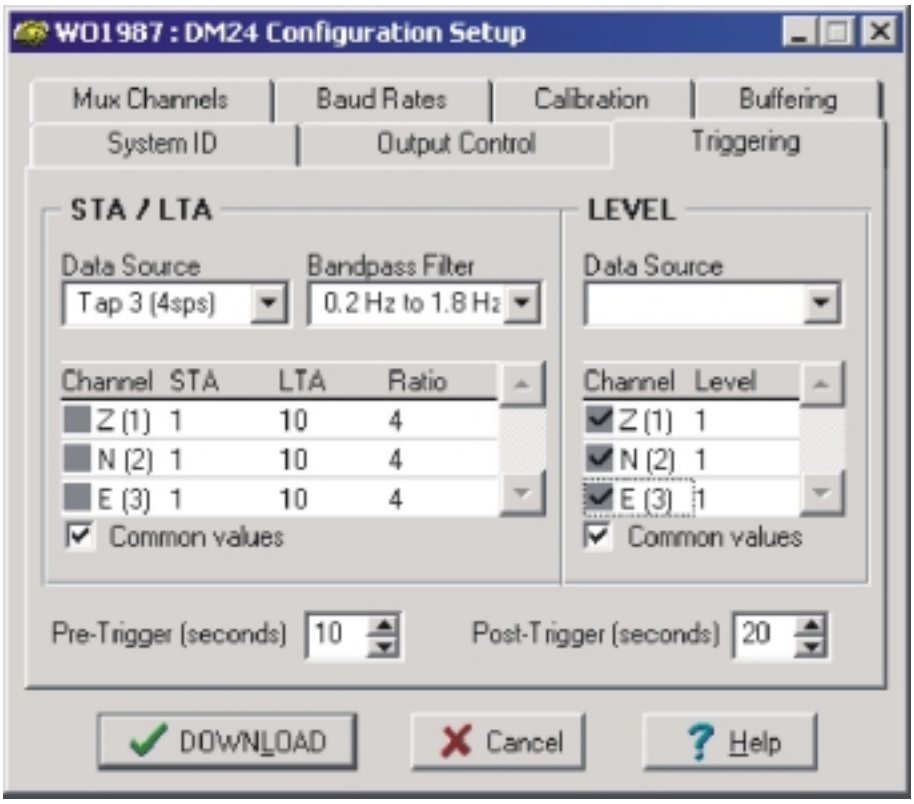
The user can also specify the pre-trigger and post-trigger data intervals. These values determine the minimum length of data that will be saved prior to the trigger condition, and how much data will be saved after the trigger condition has lapsed. Regardless of the intervals chosen, the data for the triggered streams will begin on an even second.

If the box **Common Values for parameters** is ticked, a trigger parameter entered for one component will be used for all selected components. (BANDPASS, STA, LTA, RATIO, PRE-TRIG, POST-TRIG)



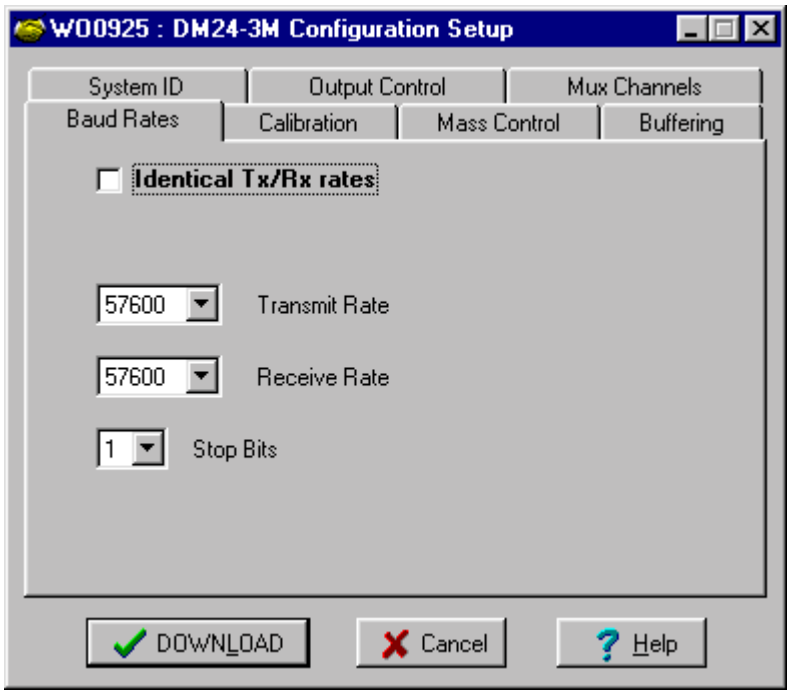
Level parameters:

The user specifies the Data Source, channels and levels by clicking on them, similar to the STA/LTA settings. The levels are specified in counts.



SETTING DIGITISER COMMUNICATION PARAMETERS

If the digitiser has a duplex link for *handshake* communications with a seismic instrument and a GPS, its COM ports must be configured to match the communications parameters of the attached devices or computers. If the digitiser is connected directly to a computer running **SCREAM, SCREAM** can auto-detect the communication baud rate under most conditions. If data from the digitiser must pass through a telemetry link or into a Guralp Storage and Acquisition Module (**SAM**), it is very important that the baud rate and other COM port parameters for the digitiser match that of the telemetry device, whether it be a modem, a radio or the **SAM**.



Data Port Baud Rate. The **Baud Rates** window of the digitiser configuration set-up allows you to program the baud rate and stop bits for the digitisers COM port. The baud rate you choose must satisfy two conditions. It must be high enough to allow all the transmission of all data generated by the digitiser at the sampling rates you have chosen. For three streams of data at 100 Hz, for example, 9600 baud will usually be sufficient. If you wish to transmit 200 Hz data, however, the baud rate must be at least 19200. The second condition for the baud rate, is that it matches that of the telemetry equipment. While modern modems often offer transfer rates up to 56 kbaud, the telephone or transmission lines may not support these rates. The same holds true for radio telemetry. Usually, transmit and receive rates of the data port will be the same. If not, you may select different data rates by removing the check in the box marked **Identical TX/RX rates**. Make sure that the COM port in **SCREAM**, the **SAM** or the communications device is also configured accordingly.

Stop Bits In most circumstances this can be left set at 1. The **Stop Bit** option gives the user the choice of setting the serial transmitted data stop bits to 2 if required over 'difficult' transmission lines. Whilst it can be an aid with say, a radio link, it will add an overhead to the data of

SENSOR CALIBRATION

The digitiser can generate either sinewave or step signals to calibrate the accelerometer.

Sinewave frequency can be from 10 Hz to 0.1 Hz (0.1 to 10 second period) and can be applied to a particular component (via the built-in relay).

The step (squarewave) calibration is specified in minutes between changes in state.

The component to be calibrated is specified by **Z**, **N/S**, **E/W** and the frequency or period by **Hz** or **Seconds** respectively. Note that only integers can be specified for frequency/period, so to generate a 0.5 Hz signal use '**2 Seconds'** or for a 0.25 second period use '**4 Hz'** .e.g. **N/S 4 Hz SineWave** will generate this signal in the calibration coil of the north/south component.

The calibration signal will be automatically disconnected after the specified time. This avoids the system being inadvertently left in the calibration mode. If the signal is required for longer this can be specified, e.g. '**5 Minutes'** will set the timer so that the calibration is disconnected after 5 minutes - this timer is then reset to its default value of 2 minutes.

NOTE: Sinewave calibration signal starts and stops on the zero crossing.

Step calibration is specified by the **Squarewave** button, which generates a positive step on the start of the next minute (of the internal clock) and a negative step the specified number of minutes later (default 2 minutes). This calibration is also disconnected after the same (specified) number of minutes after the negative edge.

4.10 DIGITAL CONFIGURATION AND CONTROL USING TERMINAL

To enter Terminal mode, right-click the digitiser icon in SCREAM, and select Terminal. Note that data transmission from the instrument are suspended while the terminal session is open, and the terminal session will automatically shut after 30 seconds of inactivity. To shut the terminal, click the X in the upper-right corner of the terminal window.

DIGITISER CONFIGURATION – FLASH DATA STORAGE

There are 5 modes available to the user with the digitisers that have the flash memory fitted (standard 64Mb, optional 512Mb). These are direct, fifo, adaptive, filing, and dual. To determine which mode is currently active, open the terminal connection to the digitizer and type *mode?* To change between these modes, open the terminal connection to the digitiser and type *direct, fifo, adaptive, or filing.* Note to enter dual mode, first enter filing mode (command *filing*), then enter dual mode (command *dual*). To select the flash memeory bahavior, type *write-once* for stop on full (the default setting), or type *re-use* for circular buffer. Note that the flash memory mode commands take effect immediately - the instrument does not need to be re-booted.

Direct (normal) Mode: The digitiser ignores the flash memory installed and transmits all continuous and triggered data, using a 255-block transmit buffer (non-flash).

Fifo Mode: The digitiser transmits all continuous and triggered data, and uses the flash memory to expand the capacity of the transmit buffer.

Adaptive Mode: Unacknowledged data (i.e. the interruption of the serial link) are automatically recorded to the flash memory. When the connection is restored, both the real-time (priority) and recorded data (using remaining overhead) are transmitted, and blocks do not necessarily arrive in sequence.

Filing Mode: The digitiser records all data to the flash memory. When in this mode, the unit transmits only 'heartbeats' which are status-only messages informing the user that it is recording data and giving the number of recorded blocks in flash memory. To transmit the recorded data, right click on the digitiser icon in SCREAM and select Download data.

Dual Mode: Continuous data are handled in Direct mode, and triggered data are handled in Filing mode.

There are more commands for when using the digitiser in filing mode through the terminal connection. These allow the user to define more accurately what data the digitiser sends from the flash. The parameters should be set before downloading.

Status-only	Replay only the status blocks.
all-data (DEFAULT)	Replay all sample rates.
all-times (DEFAULT)	Replay all data regardless of time stamp.
Stream xxxxxx	Only data with stream-id xxxxxx
nn s/s	i.e. *04 s/s* , Replay any streams with specified sample rate (overrides stream selection).
yyyy mm dd hh mm from-time	Specifies start time of the selection.
yyyy mm dd hh to-time	Specifies end time of the selection.
download	Starts the operation with the set parameters.
reset-flash	Deletes all the data in the flash file.

DIGITISER CONFIGURATION - OTHER COMMANDS

Command	Syntax	Comments
SET-ID System Identifier ? (e.g. ALPHA,) Serial # ? (e.g. 1234,00)	*interactive* NUNAME, 4339,00	Both sets of characters must include the comma in the location shown
SENSOR-TYPE	n SENSOR-TYPE n=1 CMG-40T n=2 CMG-3ESP n=3 CMG-3T n=4 CMG-3TD	
GPS-TYPE	n GPS-TYPE n = 0 no time signal n = 1 Trimble n = 2 Garmin n = 3 stream-sync	Not all versions support all combinations

NOTE: The last two digits of the serial number should set to 00 (two zeros) as the system replaces these with the characters to identify the component (Z, N, E etc) and digitiser 'tap' (0 to F) to form the '**stream-id'**.

DIGITISER OUTPUT PROGRAMMING

Command	Syntax	Comments
SAMPLES/SEC	tap0 tap1 tap2 tap3 SAMPLES/SEC example: 200 100 50 10 samples/sec	The tapN's are integers. If an illegal combination of sampling rates is specified, the system is automatically set to the default.
SET_CONFIG	SET-CONFIG *Interactive* 0007,0000 0307	See text below
TRIGGERS	n TRIGGERS Example: 5 TRIGGERS (Trigger on Z and E/W components)	To disable triggering, set: 0 TRIGGERS *The binary bits that make up n (an integer less than 8) indicate the components to which the trigger algorithm will be applied.* *001 = trigger on Z* *010 = trigger on N/S* *100 = trigger on E/W*

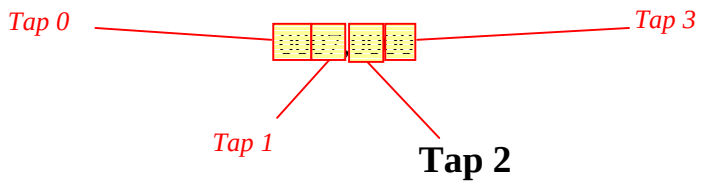
TRIGGERED	tap components TRIGGERED Example: 0 7 TRIGGERED (In case of a trigger, save all three components from tap 0)	*tap: 0-3 indicates the tap number from which data should be transmitted in case of a trigger components: like the triggers command.*

Explanation SET-CONFIG

The 'registers' are set-up by simply defining an 8 digit 'hex' code corresponding to the required contents, the most significant byte (2 hex digits) corresponding to the first tap (#0) and the least significant byte the last tap (#3).

When setting the configuration all 8 digits should be entered with the , [comma] as shown.

For example, to select all 3 components of a standard CMG-DM24 output at 100s/s the code is 0007,0000



For tap1: 07 in hex = 0111 in binary = channels 0,1,2

The environmental channels can be selected (when the hardware is fitted) in a similar fashion, but in this case only 4 hex digits are required to set the appropriate bits - msbit=channel#15, lsbit=channel#0.

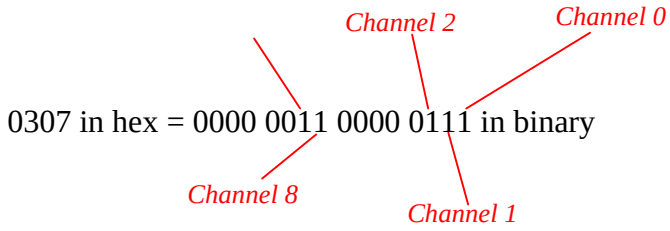
For example:

Therefore the whole **SET-CONFIG** example will look like this:-

Enter ***set-config***

Displayed Hex code to select DSP#1 'taps' { 0070,0000} _

Enter ***0007,0000***



Displayed Hex code to select DSP#1 'taps' { 0070,0000}***0007,0000***
Hex code to select mux channels { 00ff}_

Enter ***0307***

Current settings

Displayed Hex code to select DSP#1 'taps' { 0070,0000}***0007,0000***
Hex code to select mux channels { 00ff}***0307***
DSP1
Tap 0 200s/s 00 (*TAP#0 'register' setting*)
Tap 1 100s/s 07 = Chans 0 1 2 *(TAP#1 setting decoded)*
Tap 2 20s/s 00
Tap 3 4s/s 00
Mux = 0307 = Chans 0 1 2 8 9 *(Mux selection decoded)*
Port#0 9600 Port#1 9600 ok

PROGRAMMING TRIGGER PARAMETERS

Command	Syntax	Comments
BANDPASS	tap# filter BANDPASS Example: 1 5 BANDPASS This command will select data from tap 1 (maximum sampling rate 100 Hz) and bandpass filter 5	Bandpass filter parameters Filter Limits* 0 0% - 100% 1 10% - 90% 2 20% - 90% 5 50% - 90% * Given in percentage of the Nyquist frequency.
STA	n1 n2 n3 STA Example: 1 1 2 STA	Calculate short term averages for 1 s of the Z component, 1 s of the N/S component and 2 s of the E/W component.

LTA	n1 n2 n3 LTA Example: 15 20 20 LTA	Calculate long term averages for 15 s of the Z component, 20 s of the N/S component and 20 s of the E/W component.
RATIOS	n1 n2 n3 RATIOS Example: 4 6 10 RATIOS	Declare a trigger if the STA/LTA ratio is 4 for the Z component OR if it is 6 for the N/S component OR 10 for the E/W component.
PRE-TRIG	n PRE-TRIG Example: 20 PRE-TRIG	n is in seconds. When a trigger is declared, include 20 s of data prior to the trigger time.
POST-TRIG	n POST-TRIG Example: 60 POST-TRIG	n is in seconds. When a trigger is declared, include 60 s of data after the trigger ends.

SETTING DIGITISER COMMUNICATON PARAMETERS

Command	Syntax	Comments
BAUD	port# baud-rate BAUD 0 19200 BAUD 1 4800 BAUD	The DM's port 0 is assigned to data output and communication. Port 1 is used for GPS input and should remain set at 4800 baud. Port 0 may be set to one of the following baud rates: 4800, 7200, 9600, 14400, 19200, 38400, 57600 or 115200.

AUXILIARY (MUX) CHANNELS

Command	Syntax	Comments
SET-CONFIG	SET-CONFIG	See digitiser output programming earlier

If you are programming the digitiser using the **SCREAM** terminal window or a standard terminal program, you must issue the RE-BOOT command to restart the DM.

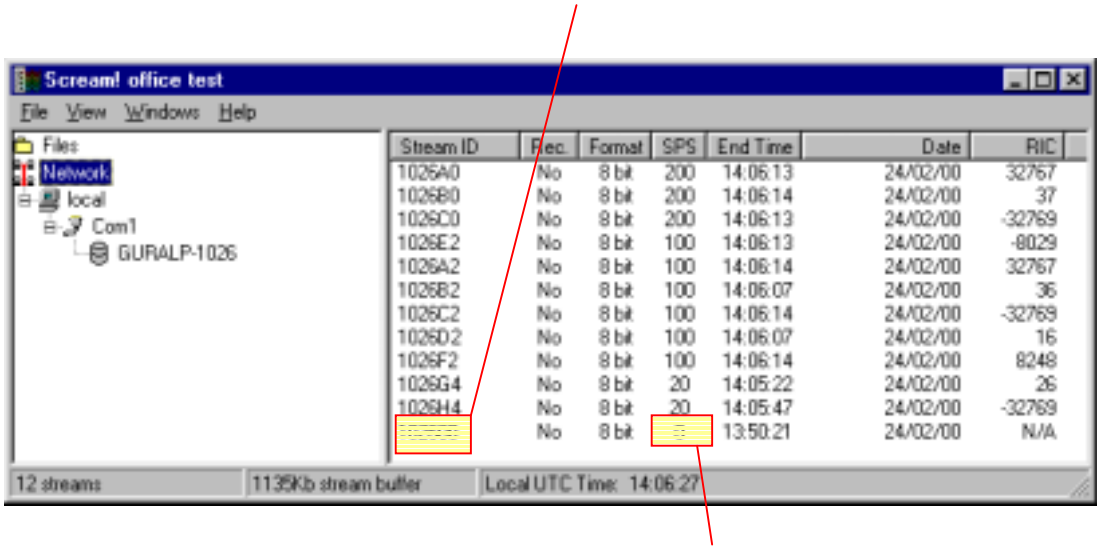
Command	Syntax	Comments
RE-BOOT	RE-BOOT *no parameters*	The command prompts the operator to confirm this operation with 'y'. The system will then automatically reset after a delay of about 2 s.

4.11 STATUS INFORMATION

STATUS STREAM

Various status information is output from the digitiser to report the system operation such as GPS and time synchronisation status. This status information is in plain ASCII text packaged in the same block structure as the channel data. There are usually 12 lines of information in a block.

To access a **Status** window right click on the **Stream ID '****00'**, (where **** is the digitiser). In the example below this is **102600**

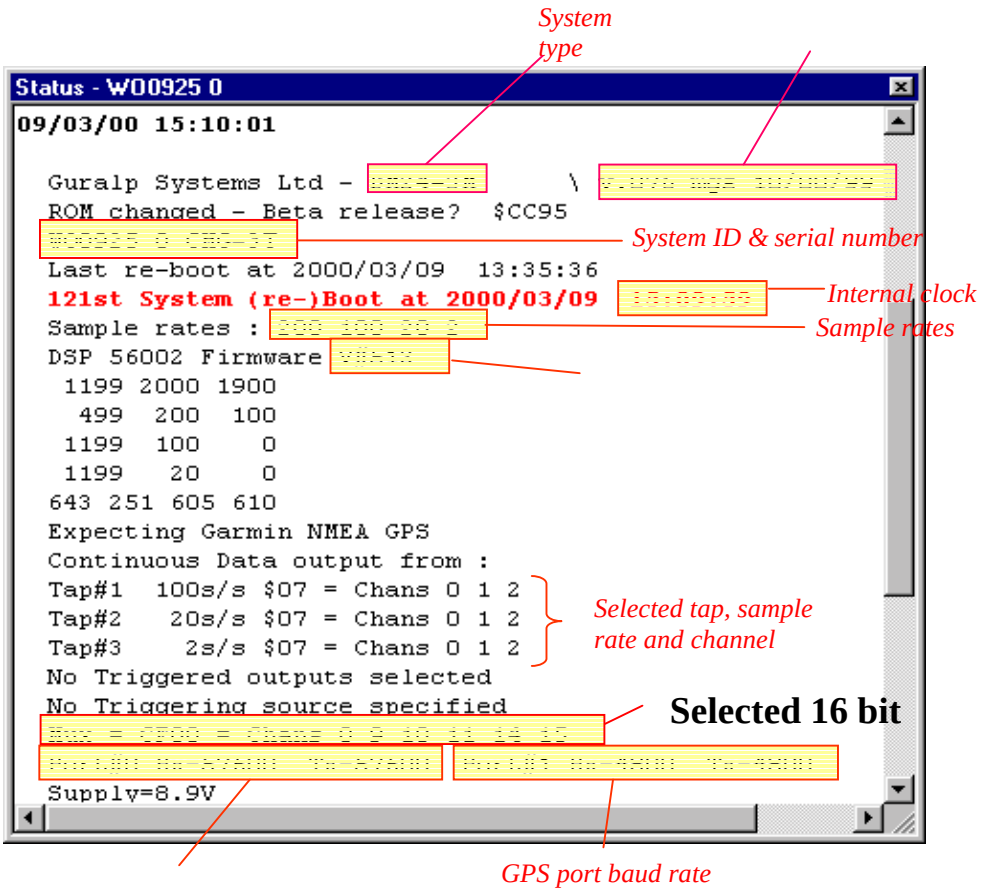


Notice this is the only stream with ‘0’samples per second

DIGITISER STATUS – BOOT UP

During boot-up the units report their model type, firmware revision number, the system-ID and serial number. This information is followed by the count of resets that have occurred and the time of this re-boot from the internal back-up clock. The following lines report the configuration of the unit sample rates, output taps selected, and the baud-rates of the serial ports.

Typical digitiser re-boot status message:


System type
Status - W00925 0
09/03/00 15:10:01
Guralp Systems Ltd –
ROM changed - Beta release? $CC95
Last re-boot at 2000/03/09 13:35:36
121st System (re-)Boot at 2000/03/09
Sample rates :
DSP 56002 Firmware
1199 2000 1900
499 200 100
1199 100 0
1199 20 0
643 251 605 610
Expecting Garmin NMEA GPS
Continuous Data output from :
Tap#1 100s/s $07 = Chans 0 1 2
Tap#2 20s/s $07 = Chans 0 1 2
Tap#3 2s/s $07 = Chans 0 1 2
No Triggered outputs selected
No Triggering source specified
Supply=8.9V
System ID & serial number
Internal clock
Sample rates
Selected tap, sample rate and channel
Selected 16 bit
GPS port baud rate

The system will produce this status message whenever it is powered up. If this status is reported at other times it indicates that the system has been reset by the built-in ‘watchdog’ monitor. This will occur if the system has suffered a corruption due to external noise or power dips.

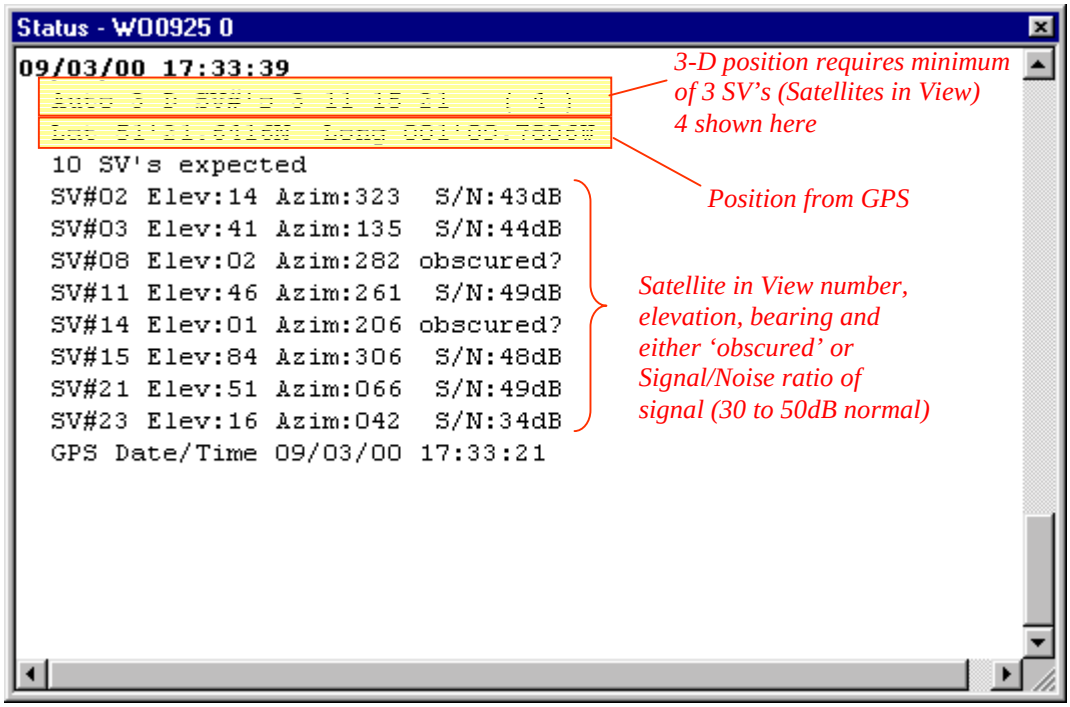
DIGITIZER STATUS – GPS PROCESS

If the digitiser does not have a GPS unit connected for time synchronisation no GPS status information is produced.

When a GPS unit is fitted, its operational status is reported and the behaviour of the time synchronisation software will also be shown.

From a 'cold' start GPS will initially report 'No GPS time' and its last position from the internally backed up status. All messages from the GPS that involve a *change* of its status are *automatically* reported, repeated status messages are not shown to avoid unnecessary accumulation of repeated information.

Initial GPS status report will be like this:


Status - WO0925 0
09/03/00 17:33:39
10 SV's expected
SV#02 Elev:14 Azim:323 S/N:43dB
SV#03 Elev:41 Azim:135 S/N:44dB
SV#08 Elev:02 Azim:282 obscured?
SV#11 Elev:46 Azim:261 S/N:49dB
SV#14 Elev:01 Azim:206 obscured?
SV#15 Elev:84 Azim:306 S/N:48dB
SV#21 Elev:51 Azim:066 S/N:49dB
SV#23 Elev:16 Azim:042 S/N:34dB
GPS Date/Time 09/03/00 17:33:21
3-D position requires minimum of 3 SV's (Satellites in View) 4 shown here
Position from GPS
Satellite in View number, elevation, bearing and either 'obscured' or Signal/Noise ratio of signal (30 to 50dB normal)

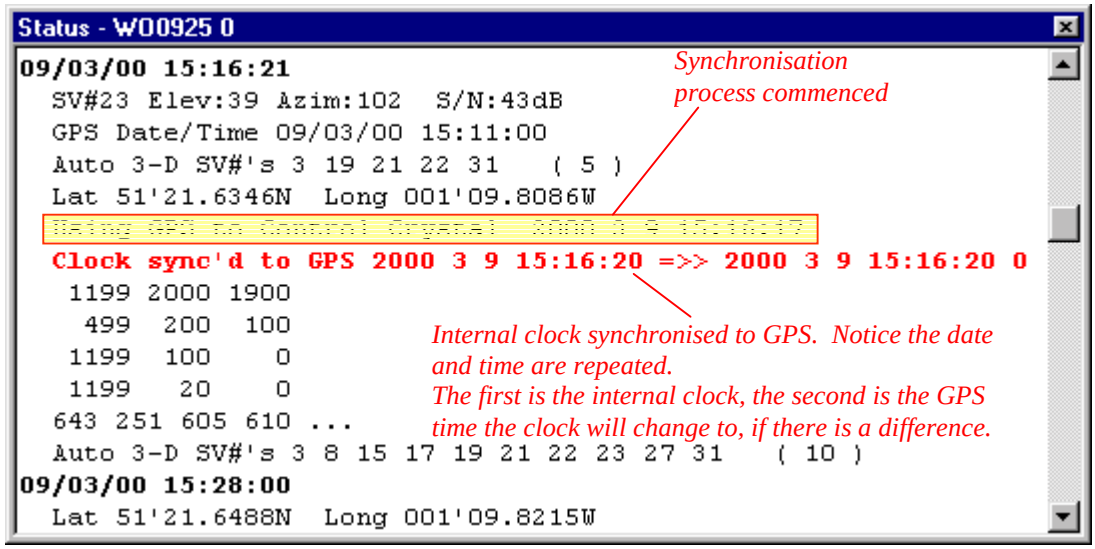
If GPS is having difficulty in acquiring satellites there can be a delay of several minutes before a new message is displayed, but normally if the system has not been moved from its previous location it should report acquisition of 1 or more satellites and GPS time in a very short time. The report will also show the satellite numbers and their corresponding signal strengths.

The internal time synchronisation and control software will wait for the GPS unit to report a good position fix (requires 3 satellites) before starting operation. The system actually waits 6 consecutive 'good' messages, which normally occur every 10 to 20 seconds.

If GPS maintains a good fix from the satellites available, the system will then switch on the control process and set the internal clock as shown by the status messages over the page.

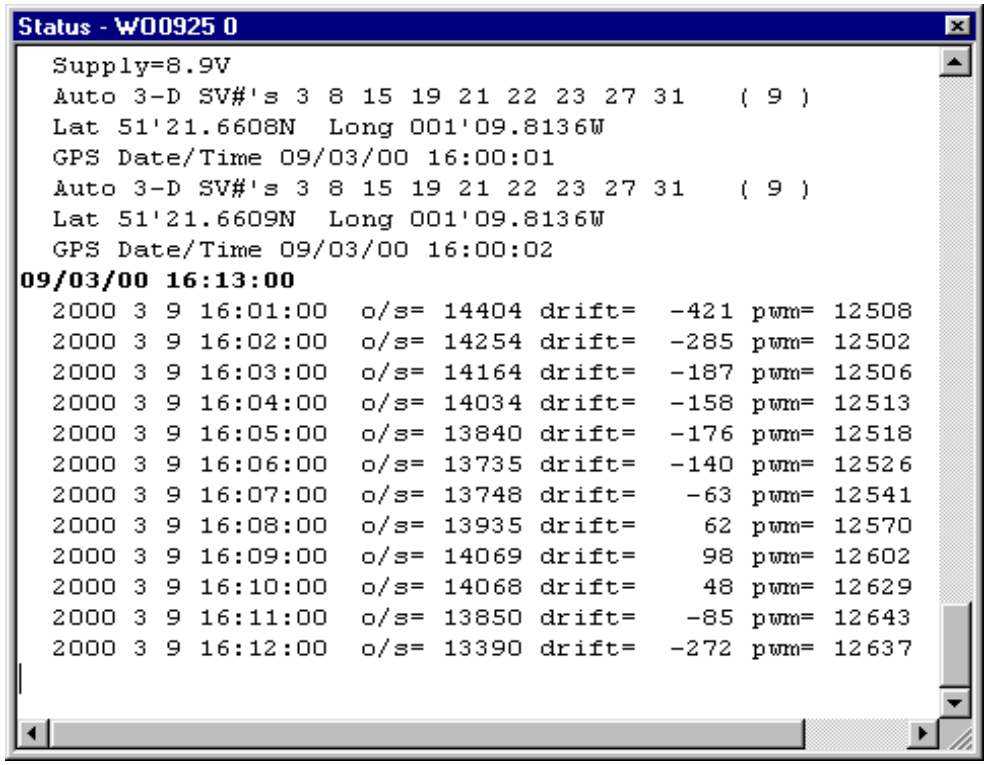
The system jam-sets its internal clock at this point to be synchronised to GPS time and will also re-synchronise the Analogue to Digital Converters so that the data is accurately time-stamped to this new reference. The data transmitted up-to this point will be stamped with the time from the internal back-up 'Real-Time Clock' ; this is also now reset to this accurate time. Re-synchronisation will also result in the received data showing a discontinuity.

The control process will now attempt to keep the internal time-base synchronised to the GPS 1 pulse per second output by adjusting the voltage controlled crystal oscillator. The control algorithm has two stages - initially it compares its internal 1 Hz time-base with the GPS 1pps and adjusts the voltage control to minimise the error. Once this has been achieved it then controls the crystal to minimise both the 'phase error' (offset between its internal 1 Hz and GPS) and the drift (frequency error) relative to GPS. During the control process the system reports the measured errors and the control signal applied, as a 'pwm' value - Pulse Width Modulation - digital to analogue conversion.


Status - WO0925 0
09/03/00 15:16:21
SV#23 Elev:39 Azim:102 S/N:43dB
GPS Date/Time 09/03/00 15:11:00
Auto 3-D SV#'s 3 19 21 22 31 (5)
Lat 51'21.6346N Long 001'09.8086W
Clock sync'd to GPS 2000 3 9 15:16:20 =>> 2000 3 9 15:16:20 0
1199 2000 1900
499 200 100
1199 100 0
1199 20 0
643 251 605 610 ...
Auto 3-D SV#'s 3 8 15 17 19 21 22 23 27 31 (10)
09/03/00 15:28:00
Lat 51'21.6488N Long 001'09.8215W
Synchronisation process commenced
Internal clock synchronised to GPS. Notice the date and time are repeated.
The first is the internal clock, the second is the GPS time the clock will change to, if there is a difference.

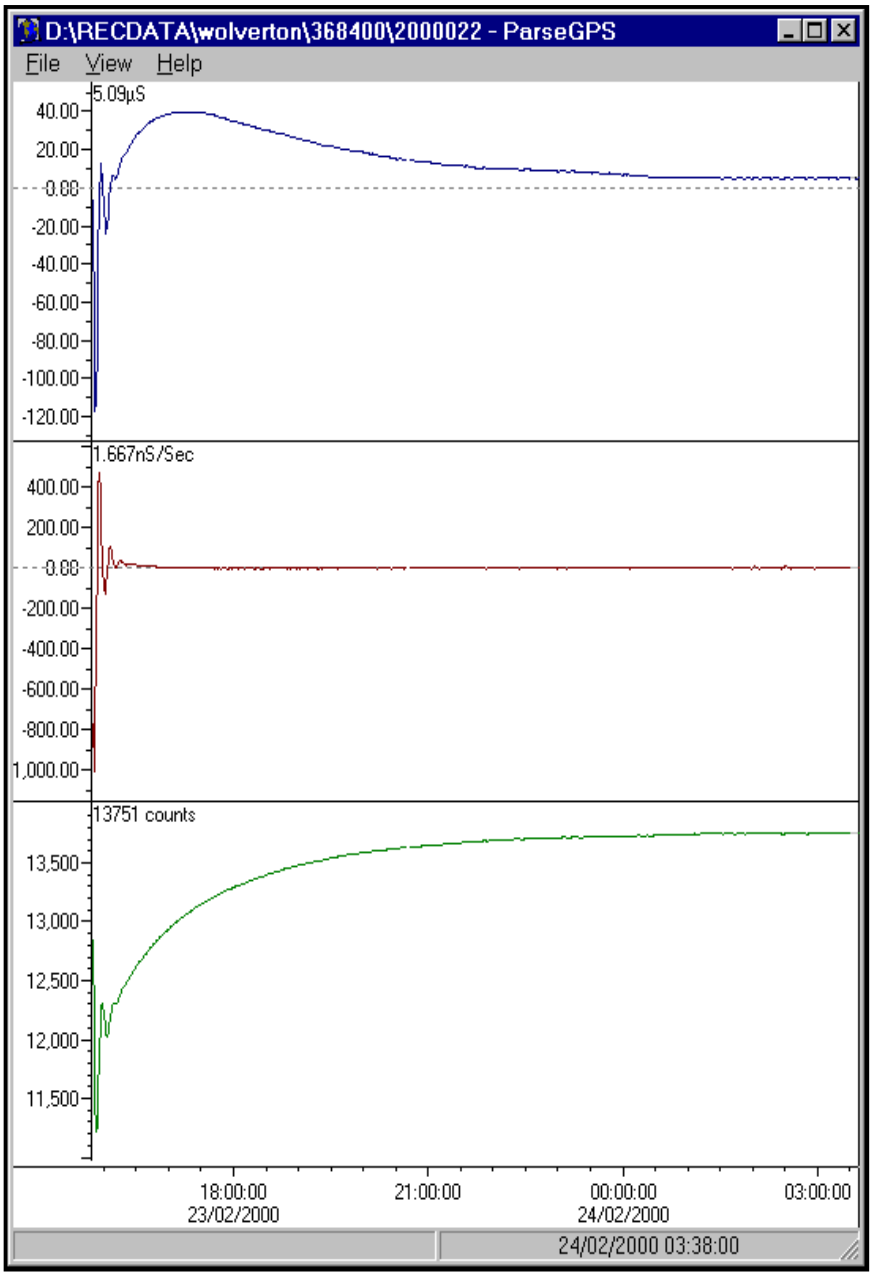
During the initial 'coarse' adjustment only the coarse voltage control is used and no 'drift' calculation is made (drift is initially shown as '0'). If the system is operating in a similar environment to that when the system was last powered (i.e. same temperature) the saved control parameters will be appropriate and the system should rapidly switch to the 'fine' control mode.

The system reports its control status and parameters each minute as shown below:



The offset and drift figures are the total accumulated error measurements during the previous minute in time-base units (nominally 0.5 µsec). To convert the figures to time, divide by 120 (60 * 2) to give micro-seconds. In a stable temperature environment the system should soon settle down showing an offset error of only a few thousand (average error < 100 µsec) and a drift rate under 100 counts (< 1 in 10^{-6}).

The screen shot below shows, from the top graph down, the offset, drift and pwm of a digitiser internal clock tracking and homing-in on a GPS clock pulse over approximately a twelve hour period.



Offset or phase error between digitiser internal 1Hz and GPS 1pps.Closes in to less than 5µs

Drift or frequency error between digitiser internal clock and GPS

PWM – Pulse Width Modulation control signal applied to a DtoA to control internal clock/GPS error

The above graphical image was printed from a Guralp plot module to demonstrate the effectivenes of digitiser clock sychronisation and subsequently time stamped data.

DIGITIZER STATUS – EVENT TRIGGERS

All event triggers appear in the status stream, along with the type of trigger (sta/lta or levle) that declared the event. The status stream may be recorded (will be as a text file), and event extracted using the grep command.

INFO BLOCK

The Information Block contains instrument-specific information. The information block data is uploaded to the digitizer at the factory in Intel Hex format, similar to the method used for flash firmware upload. The terminal command

sendinfo

causes the info block to be transmitted, and it will appear in the "IB" stream. The info block is also reported as part of the bootup message in the status stream.

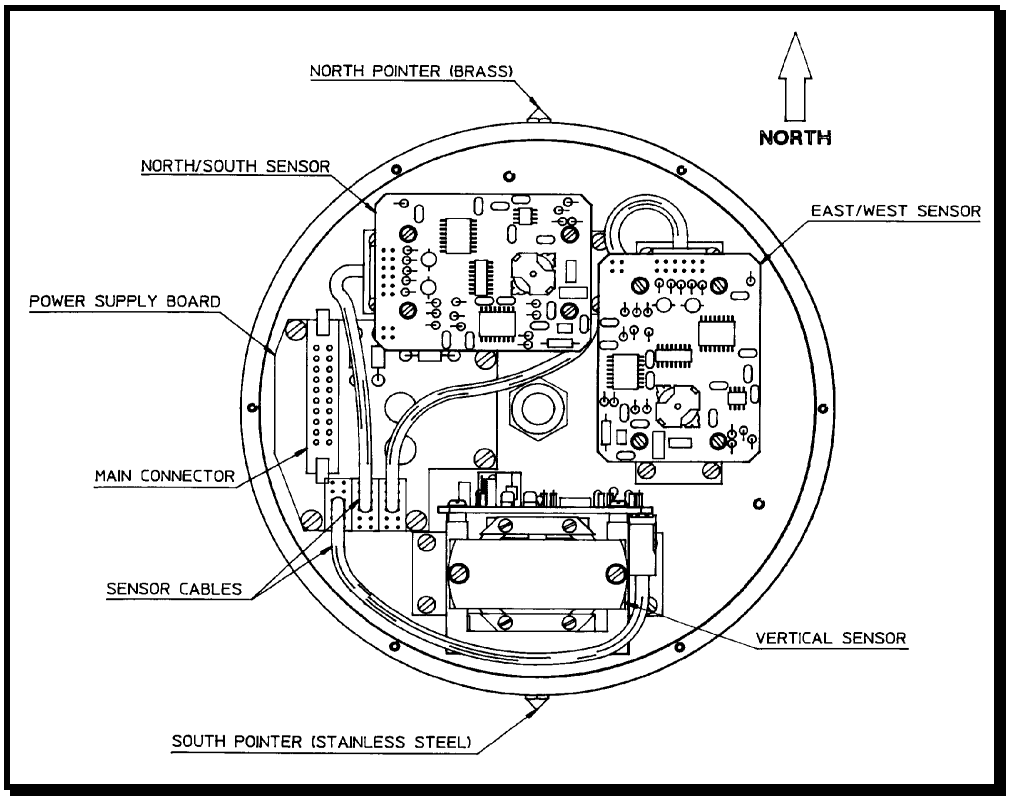
The Information Block typically includes such information as:

Serial Number
Sensor Type (velocity or acceleration)
Poles and Zeros
Sensor Calibration
Sensor Response
Digitizer Calibration

5.0 CMG-5TD

5.1 SENSOR DESCRIPTION

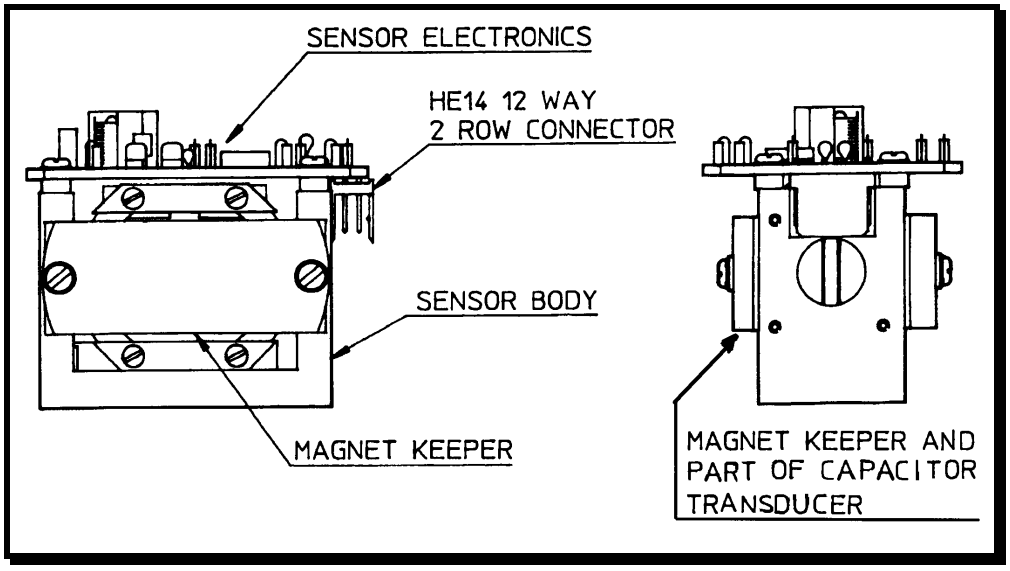
The mechanical construction of the three-component CMG-5T accelerometer and the three orthogonal sensors is shown in the figure below.



The construction of the accelerometer casing is hard-anodised aluminium and 'O' rings are used throughout the design to ensure that the housing is completely waterproof.

The mass of the vertical and horizontal components is attached to the rigid sensor frame with parallel leaf springs. The geometry of the spring spacing and the symmetrical design ensures large cross-axis rejection. The movement of the sensor mass is completely rectilinear as opposed to a pendulous design.

The sensor mass is centered between two capacitor plates which are also part of the linear feedback transducer.



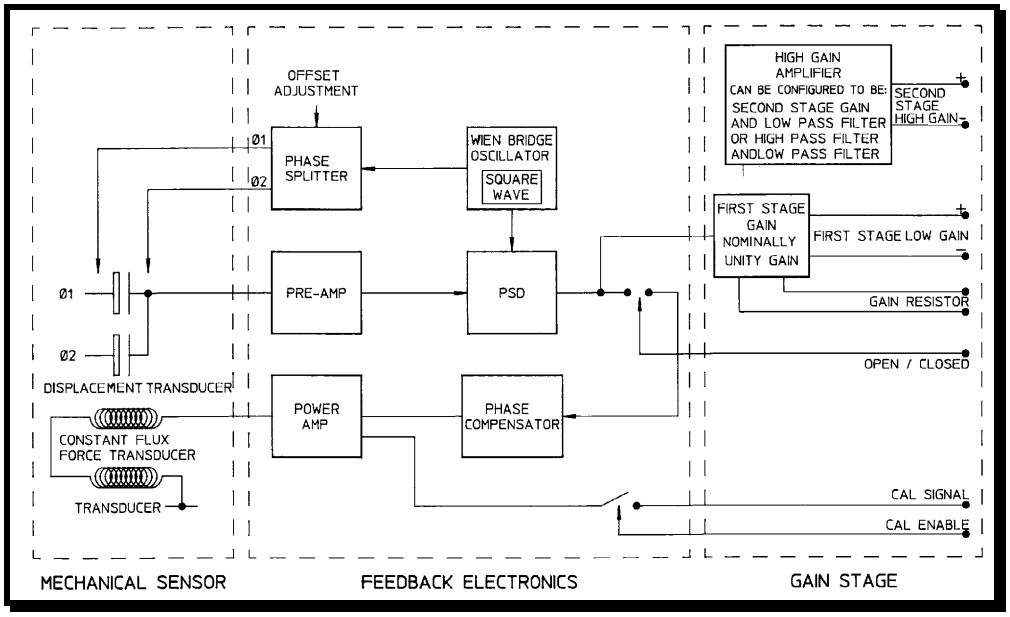
The feedback coils are attached on either side of the sensor mass and form a constant flux force feedback transducer.

Identical mechanical construction is used for both the vertical and horizontal sensors. However, in the case of the vertical sensor, the mass spring system is adjusted to balance out the vertical ground acceleration.

CMG-5T does not require a mass locking mechanism for transportation.

The individual sensors are mounted directly onto the base and each sensor electronics is fixed onto the rigid sensor frame. A single row, 12-way surface mount R/A Molex connector is used to connect each sensor to the main power supply PCB.

The block diagram shows the organisation of the signal and feedback circuits of the CMG-5T accelerometer.



The capacitive transducer in the form of a differential capacitor is formed by the mass and the capacitor plates energised with a two-phase transformer driver. The in phase amplified capacitive transducer signal is demodulated with a phase sensitive detector. The accelerometer feedback loop is completed with a feedback loop compensator and a feedback force transducer power amplifier.

The differential output amplifier scales the sensor output sensitivity and a second stage amplifier is configurable as an additional cascaded gain stage (normally *10) or as a unity gain high pass filter.

5.2 THE FORCE TRANSDUCER

Force feedback strong motion accelerometers which use a coil and magnet system to generate the restoring feedback force are inherently dependent upon the constancy of the field strength produced in the magnet gap. Although the high quality magnets used in the CMG-5 are exceedingly stable under normal conditions, the flux density can be affected by the external magnetic field generated by the feedback transducer coil in areas where the background seismic noise is much higher than that of vaults built in seismically stable locations.

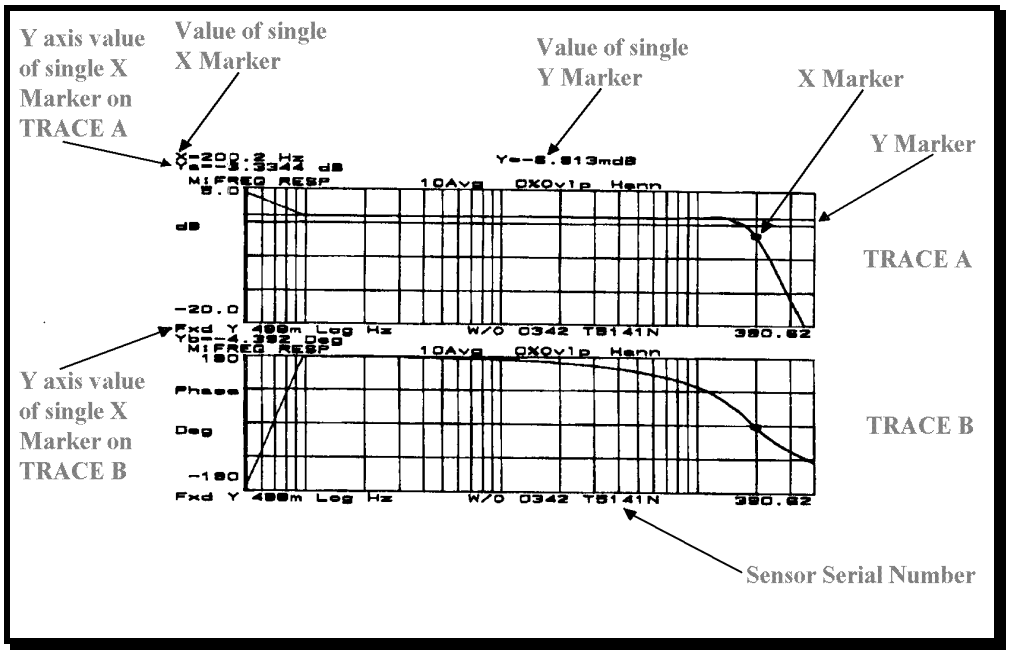
In order to minimise the feedback force transducer non-linearities a symmetrical system of two magnets and two force coils are used in CMG-5T sensors. The force produced by each coil is additive while increased flux in one coil is cancelled by a corresponding decrease in flux in the other, thus eliminating any non-linearity due to lack of symmetry.

5.3 FREQUENCY RESPONSE

The frequency response of each component is provided as amplitude and phase plots.

When testing the instrument, to confirm that it meets its design specification, it is most convenient in any one test to concentrate the range of frequencies over about 3 decades (i.e. 1000:1) of excitation frequencies. Consequently the normalised frequency plots of each component are provided. In each plot, the frequency cut-off value (often quoted as -3dB or halfpower points) are marked. The frequency responses are normalised (unity gain) in order to show the corner frequencies.

Frequency response tests are always performed on every sensor produced at Güralp Systems Limited and records are archived for future reference.


Y axis value of single X Marker on TRACE A
Value of single X Marker
Value of single Y Marker
X Marker
Y Marker
TRACE A
Y axis value of single X Marker on TRACE B
TRACE B
Sensor Serial Number

Frequency response from 488 mHz to 390.62 Hz
TRACE A:- Y axis in dB.
TRACE B:- Y axis in degrees.

5.4 SENSOR TRANSFER FUNCTION

It is convenient for most users of seismometers to consider the sensors as 'black-boxes'. Thus the details of the internal mechanics and electronics need not be known, but only the overall effect of the instrument in producing a usable output signal V from the desired input variable of x is required. The generic form of such a transfer function (in terms of Laplace variable, s) is given as:

$$\frac{V}{x}(s) = G * A * H(s)$$

where:

G: Is the acceleration output sensitivity (gain constant) of the instrument relating to the actual output to the desired input over the flat portion of the frequency response. Output sensitivity is supplied in the calibration sheet.

A: Is a constant which is evaluated to make the magnitude of A * H(s) unity, with no dimensions over the flat portion of the frequency response. In practice it is possible to design a system transfer function with a very wide range of flat frequency response. For convenience, the normalising constant A, is calculated at a normalising frequency value fm = 1 Hz, with s = j fm, where j = √-1. The value of A is given in the poles and zeros table.

H(s): The transfer function of the sensor can be expressed in factored form.

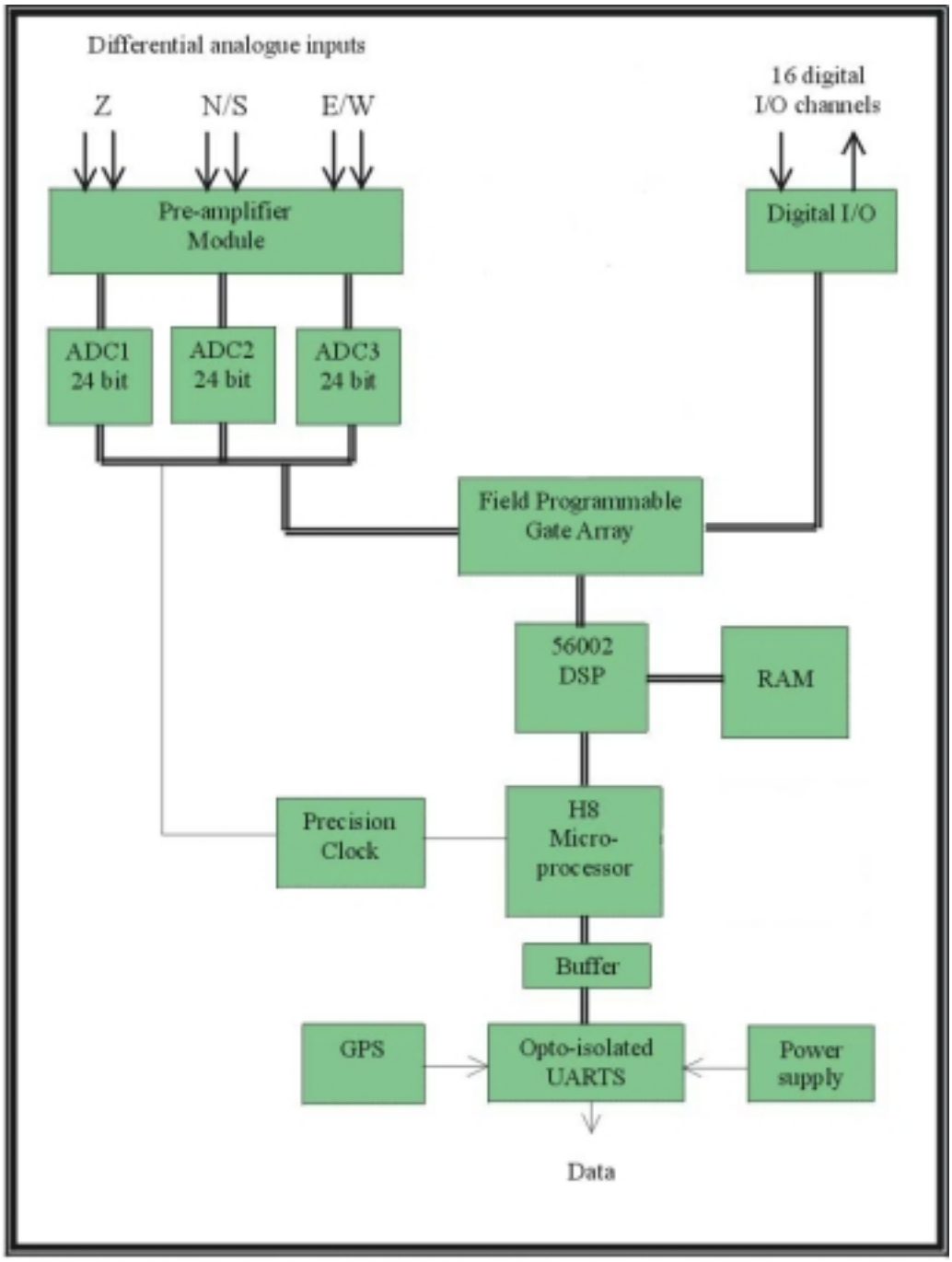
$$H(s) = \frac{\sum_{n=1}^{N}(s - z_n)}{\sum_{m=1}^{M}(s - p_m)}$$

z_n : are the roots of the numerator polynomial, giving the zeros of the transfer function,

p_m : are the roots of the denominator polynomial giving the poles of the transfer function. See: poles and zero table.

5.5 DIGITIZER DESCRIPTION

The DM24 system design block diagram is given below. Each section of the block diagram represents a separate printed circuit board. Depending on the CMG-DM24 configuration, the printed circuit boards are stacked up either as circular PCB, square circuit boards or long and slim PCBs for the borehole digitiser.



The high resolution digitiser utilises the Crystal Semiconductor CS5321/2 chipset and Motorola 56002 DSP. The CS5321/2 provides data at 2,000 samples per second, triggered by the H8 timing system, to the 56001 DSP. The DSP can control from 1 to 3 ADCs and process the data.

The system is designed around a low power, high performance 16bit microprocessor (Hitachi H8/500 series). This features a large address space (1Mb - 16 *64k pages) for data storage and manipulation and many integrated functions such as multiple timers and serial I/I ports.

The modular (paged) structure of the processor architecture is used to advantage in the modular design of the system, each module being assigned to a separate 'page'. Each module is associated with an 'I/O' function and can simply be added to the system at an available page. Every module includes 32k of RAM which is used for data buffering and workspace for the module's software.

An important feature of the system design is it's ability to synchronise the sampling of the analogue to digital converter to an external time reference so that data samples are accurately time stamped (at the source). The microprocessor time-base serves as the system time reference and can be synchronised and tuned to an external reference such as GPS to maintain sampling accurately synchronised to UTC. To avoid the cost and power consumption of multiple GPS receivers in larger arrays the systems can also be synchronised to a centrally transmitted time reference using a scheme similar to that employed by the National Radio Time Standards (WWV,MSF and DCF77). As this only involves sending 2 characters per second it can utilise a low band-width, even half-duplex link.

To achieve the high degree of timing precision required for a 24 bit digitiser system the microprocessor time-base is run from a precision voltage controlled oscillator which is software controlled from the external reference so that its frequency is accurately set and maintained with temperature and ageing. The control is sufficiently accurate to maintain precision sampling for long periods (several hours) in the absence of an external reference once the system has stabilised.

All the timing functions are derived via the internal timer/counter channels from the precisely set processor frequency so that sampling and time-stamping are accurately maintained with reference to UTC. The system also automatically compensates for the pure time delay introduced by the digital filtering/decimation of the DSP which provides data output at different sample rates simultaneously.

The main microprocessor board incorporates a battery-backed Real-Time Clock and RAM which is used to set the systems internal software clock at start-up independent of the availability of the external time reference. The RAM is used to store system parameters such as the optimum control voltage setting for the system time-base and the system configuration.

The microprocessor module includes the (multi-tasking) system operating software in 64K EPROM. This module also has 512k of static RAM for system workspace and data buffering depending on the system requirements (number of data channels and sample rates).

The microprocessor serial port (19,200 Baud) provides an interactive interface for system setup and configuration. This port is known as the terminal port. Unlike the GPS serial port or the data port, the terminal port is not optically coupled to the outside world. Care should be taken not to run a terminal over very long RS232 cables.

The DSP software consists of 4 cascaded programmable filter/decimation stages allowing multiple data output rates to be simultaneously selected. The first stage is set to decimate the data by 10 resulting in a data output rate of 200 samples/sec. The following 3 stages can be set individually for decimation factors of 2, 4, 5, 8, and 10 allowing data to be output at lower rates requiring less storage and transmission bandwidth. For example, a system can be configured to provide data at 200, 50, and 10 samples/sec covering the whole of the seismological broad band range.

The configuration of the DSP is programmable (in the field) via the host H8 microprocessor. The H8 communicates with the DSP via its high speed 8-bit 'host port', which allows the operating mode/configuration to be altered and the resulting processed/filtered data to be acquired.

The primary digital interface for the systems is the multiple serial port card. Each card can contain 1 or 2 dual UARTs (Universal Asynchronous Receiver Transmitters) and upto 2 cards can be fitted to a SAM/DM unit. This allows a system with upto 8 serial ports to be configured.

On a DM unit with analogue inputs a serial port is usually configured to send the data packets to a (local) SAM unit for storage/acquisition or via a modem or radio link to the central recording station. The second serial port is available for use with a local GPS receiver for time synchronisation, or alternatively the first (data) port is used for time synchronisation from the central station.

The multiple serial port card is usually configured as several data inputs for a SAM unit allowing it to collect data from upto 8 other SAM or DM units located locally, using RS232 or RS422 links, or more remotely using radio links or telephone modems.

Each of the serial ports on a module can be configured for a wide range of standard baud rates (with different settings available for transmit and receive channels), allowing a wide range of data links to be used depending on the required data rates.

The first dual UART supports full modem interface on one port and hardware handshake on the second. The second dual UART is configured for data line interface only, supporting software handshake. Each dual UART is optically isolated to avoid ground loops that could degrade the performance of the ADC's.

The serial port module includes 32k RAM for data buffering and formatting by the transmission/reception process.

5.6 DATA TRANSMISSION & DATA BLOCK STRUCTURE

The block structure of the SAM/DM data format (which does NOT use BDTS format) lends itself to a simple block transmission/acknowledge protocol for transmission of the data between multiple SAM/DM units and central data acquisition systems.

To send blocks of data from one system to another each block is packaged in a 'transport' layer, which consists of a short block header and a checksum tail. The header consists of 4 bytes. The first is always an ASCII 'G' and the second is an incrementing block number (modulo 256). The other 2 bytes contain the length of the data block (binary, Motorola byte order). The checksum is also a 'word' (16 bit) being the sum of all the **bytes** in the data block **and** the 4 header bytes.

To optimise the use of available transmitter bandwidth the transmitted data block is truncated to the actual data length. As the systems currently only have 24 bit resolution the redundant most significant byte in 32 bit data blocks is also not included in these blocks i.e. 24 bit (3 byte) records are transmitted. This reduction is only applied to the *difference* records - the first and last *absolute* values are still transmitted as 32 bit values.

The transmission header consists of 4 bytes

Fixed identifier	ASCII 'G' (hex 47)
Block sequence number	0 - 255
Block size in bytes (excludes header and checksum)	Most significant byte Least significant byte

The digitiser units transmit data as complete blocks become available without any flow control except that provided by a simple positive/negative acknowledge (**ack/nak**).

Acknowledgement of received packets is not necessary as the transmitter only waits for a nominal 100 mSec before moving onto the next block, if ready. To acknowledge correct reception of a block the receiver should reply with an '**ack**' character (here defined as hex 01) and the least significant byte of the block's 'stream-id'. This allows for a system which has a simple broadcast acknowledgement via a common link (radio band) to many systems that are part of an array, each system is able to identify its own **ack/nak** by matching the identifier byte. Reception of a positive acknowledgement will enable the transmitter to terminate its wait timer and immediately proceed to the next block.

When the receiver detects a transmission error it should reply with a '**nak**' (here defined as hex 02) and the identifier byte. This will cause the transmitter to re-send the block of data.

DATA BLOCK STRUCTURE

Block Header

All elements of the GCF data block can be considered as long words (4 bytes or 32 bits).

The GCF block header consists of 4 elements (16 bytes) as shown

System-ID	32 bit number (base 36) - see below			
Stream-ID	32 bit number (base 36) - see below			
Date/Time	15 bit Day number		17 bit Second number	
Format	R.F.U.	s/sec	compression	block size

The first element contains the unique identifier for the system from which the data came. This is usually a six character string encoded in base 36 i.e. each character can be extracted by taking the number modulo 36 and converting to the characters 0 - 9 and A - Z. Only positive integers are allowed (most significant bit=0) limiting the range of values to 0 - 7FFF,FFFF in hex (2,147,483,654 decimal) or ZIK0ZJ in base 36. This field can be set to any convenient unique identification number by the user, but units are shipped from the factory with this set to the factory Works Order number e.g. WO1234.

The second element identifies the stream of data i.e. source as horizontal or vertical sensor and its origin from the digitiser. This again uses base 36 encoding, but this field should not be changed as it is dynamically set according to the configuration of the digitiser.

This is best viewed in its base 36 form i.e. as 6 alphanumerics. The 4 most significant characters are the instrument serial number (decimal) and the 2 least significant characters encode the sensor component and digitiser output.

Stream-ID	digit 4	digit 3	digit 2	digit 1	Z,N or E	see text
	serial number				comp	source

The Guralp CMG-DM24 digitisers can output upto 4 data rates per component simultaneously.

The third header element contains the date/time information as a 15 bit day number packed with a 17 bit second number. The second number is the time since midnight - maximum 86,399 normally but possibly 86,400 in the case of a ‘leap second’. The day number increments on the roll-over of the seconds count at midnight. The origin of the day number (day zero) was 17th November 1989. Thus the date/time can be uniquely decoded for the next 80 years.

The final header element defines the format of the data in the block, i.e. compression, sample rate, size etc.

The most significant (first) byte is currently unused and is set to zero.

The next byte contains the sample rate (s/sec in binary). If this field is zero this indicates that the block contains status (text) information.

The third byte is used to specify the compression format for all the data in the block. The 3 least significant bits are used to indicate whether the data elements (32 bits) contain 1, 2 or 4 sample points - i.e. a value 4 indicates that the data records should be treated as 4 8 bit differences, a value 2 means the data are 2 16 bit differences and the value 1 the data are a single 32 bit difference.

The fourth byte contains the count of the number of data records (32 bits).
The product of these last 2 bytes can be used to calculate the total number of sample points in the block.

Block Data.

First absolute value	32 bits
First 1, 2 or 4 differences	1*32bit, 2*16bit or 4*8bit values
	....
	....
Final 1, 2 or 4 differences	same format 1, 2 or 4 differences
Final absolute value	32 bits

The first data record in the block, following this format record, is the initial 32 bit absolute value (forward integration constant). The last record is the final 32 bit absolute value (reverse integration constant). Between these are the specified number of data records. Each data record contains the specified number of 8, 16 or 32 bit differences from the previous value. The first difference is always zero as it corresponds to the first sample.

By definition each data block starts on an integral second and contains an integral number of seconds of data. The data block has a *maximum* size of 1024 bytes (16 byte header + 8 bytes for start and end value leaves 1000 bytes for data differences e.g. at 8 bit compression the block will contain 1000 sample points i.e. 10 seconds of data at 100 s/s - using minimum compression (32 bit) only 2 complete seconds of data can be fitted in a block at this sample rate - 2*100*4 = 800 bytes). Changes in signal level will result in the compression algorithm having to change the format so blocks are not necessarily filled to the maximum specified capacity, when the next second of data requires more dynamic range.

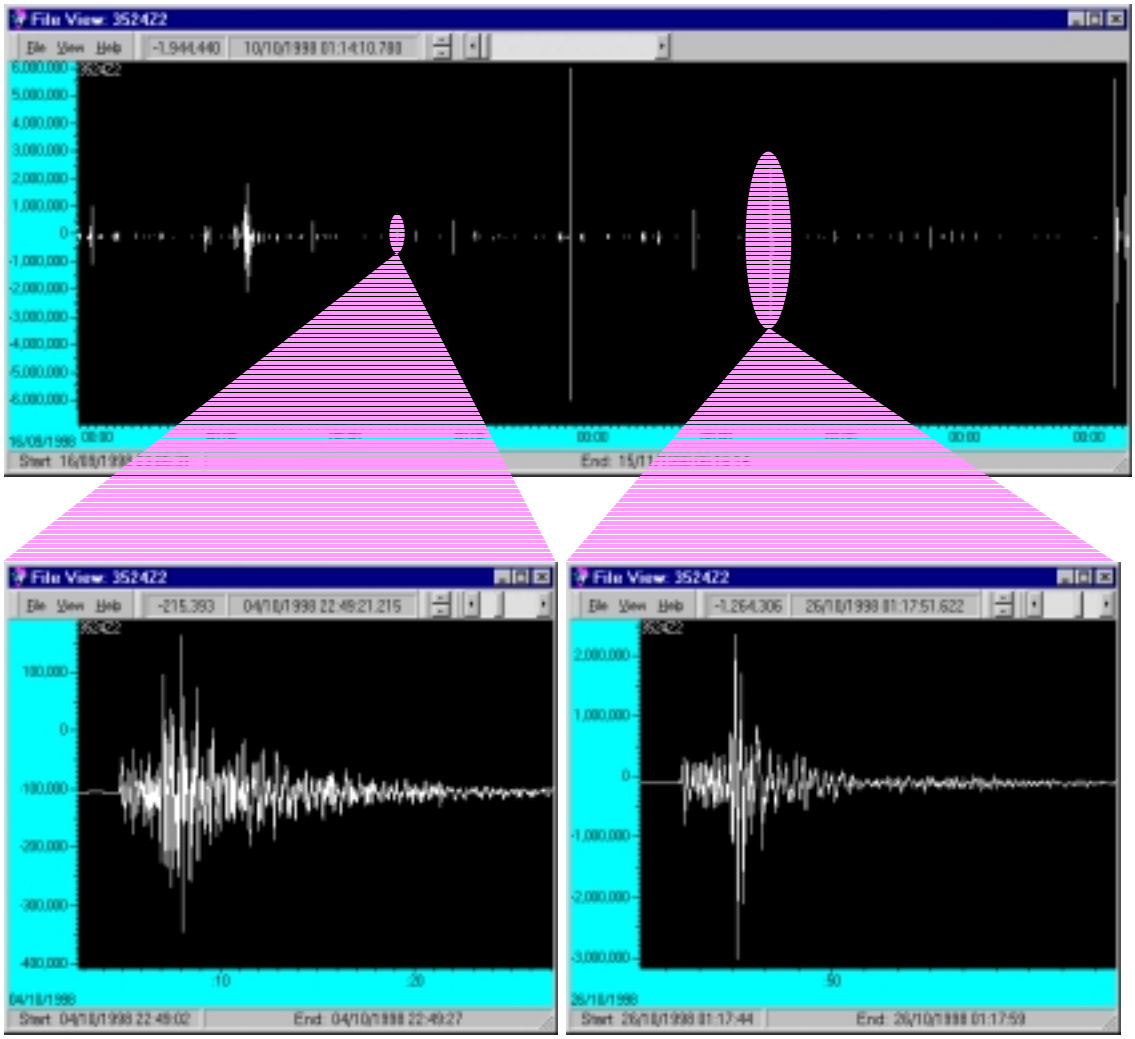
The data has this format when processed and stored in the DM and SAM units (maintaining data values on word boundaries in the processor), but when data blocks are transmitted via the serial ports, blocks of 32 bit differences have the redundant most significant byte (of the difference values) omitted to optimise the efficiency of the serial transmission.

5.7 STA/LTA TRIGGER

In it's standard configuration the digitiser outputs continuous data at a user-selectable sample rate. An additional powerful feature of the digitiser is the ability to simultaneously run a

STA/LTA event triggering algorithm in parallel with the continuous acquisition. This permits the system to record continuously at a relatively low sample rate, and record at a much higher sample rate during short periods when triggered. Parameters controlling the triggering algorithm, and controlling the data output once the system is triggered, are all selectable by the user, permitting the maximum flexibility of operation and the most efficient use of available storage space.

Shown below in the upper window, is an example of a data stream recording over a two month period. Two seismic events are shown highlighted in the two lower windows which, given suitable triggering parameters, can be recorded in greater detail at a higher sampling rate of upto 200 samples per second.



Triggering of all three components from vertical channel 100Hz tap, filter from 5 to 45 Hz

Sta = 1, Lta = 50, Sta/Lta = 10, pre-trigger = 40, post-trigger = 70

This section describes the triggering algorithm and gives several examples of typical system configurations that may be used. It is intended to be read along with the Digitiser Configuration Section of the Operator's Guide.

USING THE TRIGGERED SYSTEM -- OVERVIEW

The Digitiser Configuration Section of the Operator's Guide describes in detail how to configure the system to output continuously at up to 3 different sample rates, selectable within certain constraints by the user. Typically, you may only wish to record one sample rate as continuous data, but it may be useful to record selected time periods at a higher sample rate

The triggering algorithm used is a standard STA/LTA ratio test on a bandpass filtered signal. An individual channel, corresponding to an individual seismometer component can be defined as the trigger channel, or triggers can be permitted on any channel. Details of the various parameters related to the triggering process are given in the following sections.

PRETRIGGER BANDPASS FILTERING

As the digitiser is normally used with a Güralp Systems Limited broadband seismometer the raw data is very broadband. To enhance the performance of the triggering algorithm, the raw input data is bandpass filtered prior to running it through the triggering system. This filtering serves to maximise sensitivity within a specific frequency band of interest, and to reject noise outside this band, for example from oceanic microseisms. The system is provided with a choice of 3 inbuilt generic bandpass filters (wide, medium and narrow) which are slaved to the defined tap output sample rates defined using the samples/sec command. The filters all have a low pass corner at 90% of the Nyquist frequency of the selected tap, and the wide, medium and narrow filters have high pass corner frequencies at 10%, 20% and 50% of the Nyquist frequency respectively. For example, if we consider the 100 samples/sec tap defined above (Tap#1) the low pass corner for each filter will be at 45Hz, and the high pass corners will be at 5Hz, 10Hz and 25Hz.

The possible filter configurations are shown in the following table:

Tap#	Samples/sec	Bandwidth 1 Hz	Bandwidth 2 Hz	Bandwidth 5 Hz
0	200	10 - 90	20 - 90	50 - 90
1	100	5 - 45	10 - 45	25 - 45
	50	2.5- 22.5	5- 22.5	12.5- 22.5
	40	2 - 18	4 - 18	10 - 18
	25	1.25- 11.25	2.5- 11.25	6.25- 11.25
	20	1- 9	2- 9	5- 9
2	50	2.5 - 22.5	5 - 22.5	12.5 - 22.5
	25	1.25- 11.25	2.5- 11.25	6.25- 11.25
	20	1 - 9	2 - 9	5 - 9
	10	0.5- 4.5	1- 4.5	2.5- 4.5
	8	0.4- 3.6	0.8- 3.6	2- 3.6
	5	0.25- 2.25	0.5- 2.25	1.25- 2.25
	4	0.2- 1.8	0.4- 1.8	1- 1.8
	2	0.1- 0.9	0.2- 0.9	0.5- 0.9
3	25	1.25- 11.25	2.5- 11.25	6.25- 11.25
	10	0.5- 4.5	1- 4.5	2.5- 4.5
	5	0.25- 2.25	0.5- 2.25	1.25- 2.25
	4	0.2- 1.8	0.4- 1.8	1- 1.8
	2	0.1- 0.9	0.2- 0.9	0.5- 0.9
	1	0.05- 0.45	0.1- 0.45	0.25- 0.45

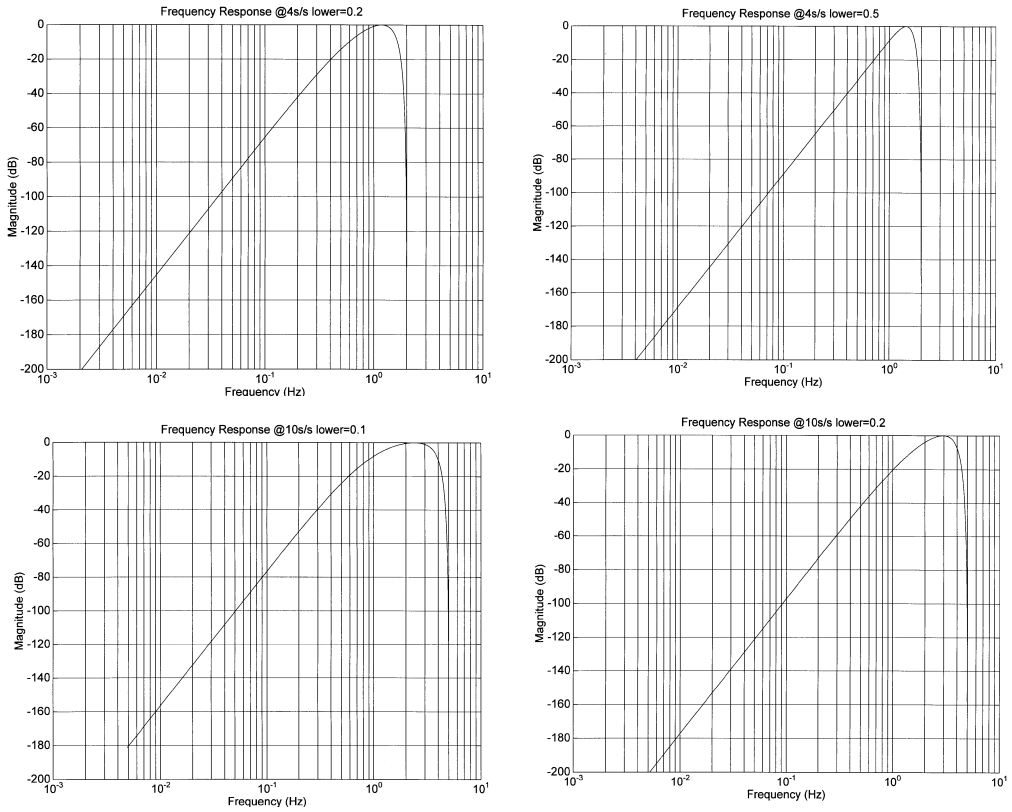
As can be seen from the list the choice of required filter will tend to define the set of permissible sample rates required. The filter combination is set using the bandpass command, which takes the tap number (0-2) and bandwidth factor (1, 2 or 5) as arguments. For example:

2 5 bandpass

defines the narrowest filter on the output from tap #2, the 20 samples/sec tap in our example, corresponding to a filter with corners at 5.0Hz (50% Nyquist) and 9.0Hz (90% Nyquist). The system response to the above command would be:

Tap#2 20 s/s Bandpass: 5.0->9.0Hz

The spectral amplitudes for the various frequency responses available are shown in the figures below.



STA/LTA TRIGGERING ALGORITHM

The triggering algorithm applied to the bandpass filtered data is a standard STA/LTA ratio test. Averages of the modulus of signal amplitude are computed over two user defined time periods, a short time average (STA) and a long time average (LTA), and the ratio of the two at each sample point is computed (STA/LTA). If this ratio exceeds a user-defined threshold, then a trigger is declared, and the system remains in a triggered state until the ratio falls below the defined threshold. The trigger works by identifying sections of an incoming data stream when the signal amplitude increases. The purpose of taking a short term average, rather than triggering on signal amplitude directly, is to reduce the probability of triggering on spurious spikes or short duration transients, and to introduce some element of frequency selectivity into the triggering process. As a rule of thumb, the short term average should be set to the dominant frequency of the events the trigger is designed to catch. The purpose of the long term average is to provide a measure of the variation in the background seismic noise, so it should be set to some value longer than the period of the lowest frequency seismic signal of interest. Obviously there is some element of trade-off in setting a value for the trigger ratio. Too high a value will result in events being missed, while too low a value will result in spurious non-seismic noise triggering the system producing false alarms. Determining an apropriate value in any given situation which maximises the number of seismic events detected while minimising the number of false alarms is a matter of experiment.

In order to capture all of a seismic event, some seconds of buffered data from before the trigger is declared are recorded. This facility is particularly useful for emergent type signals where the system triggers on a phase after the first arrival. Furthermore, some seconds of data after the system stops triggering are also recorded to ensure the coda of an event is not missed.

There are 5 parameters directly associated with the STA/LTA trigger algorithm:

sta defines the length of the Short Term Average window in seconds. Takes 3 arguments which are the values to use for each of the three seismometer components (Z, N/S, E/W)
Example: 1 1 1 sta

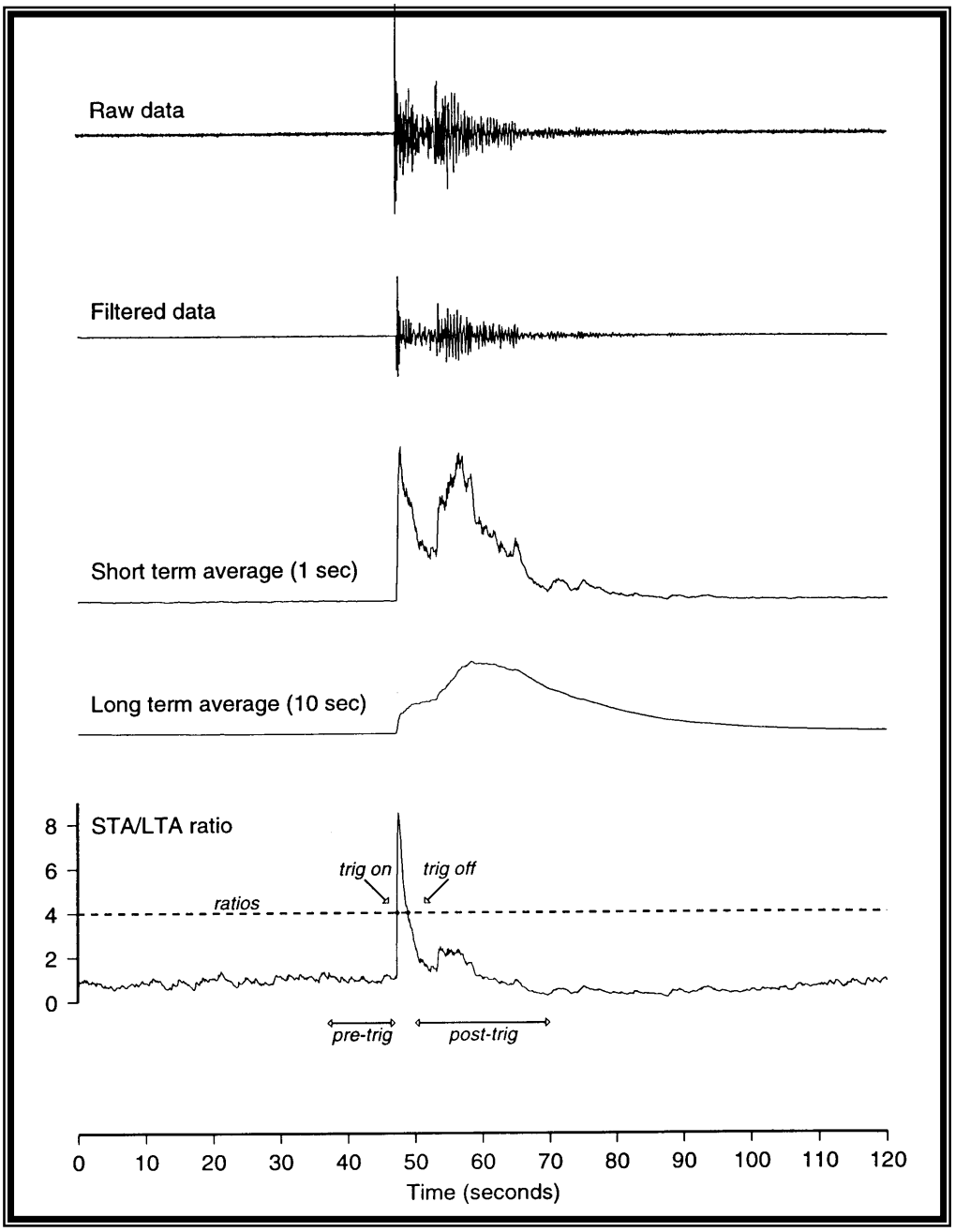
lta defines the length of the Long Term Average window in seconds. Takes 3 arguments which are the values to use for each of the three seismometer components (Z, N/S, E/W)
Example: 1 1 1 lta

ratios defines the STA/LTA ratio above which the system will declare an event. Takes 3 arguments which are the values to use for each of the three seismometer components (Z, N/S, E/W)
Example: 4 4 4 ratios

pre-trig specifies the amount of time in seconds for which data prior to the trigger will be retrieved from the buffer and output with the triggered data. Because of the block nature of the data format and compression algorithm this time is only approximate.
Example: 20 pre-trig

post-trig defines the amount of time in seconds after the trigger has ceased during which triggered data will continue to be output. Because of the block nature of the data format and compression algorithm this time is only approximate.
Example: 40 post-trig

An example illustrating the various trigger parameters is shown overleaf.



DEFINING CHANNELS RUNNING TRIGGER ALGORITHM

The filtering and triggering can be carried out on 1, 2 or 3 channels, usually corresponding to the 3 components of a seismometer. The channels to be used are specified using the command **TRIGGERS**. A trigger on any defined channel will cause the system as a whole to declare a trigger. The argument for the **TRIGGERS** command is an integer specifying with its binary bits which components to enable: 1 (001) for the first component (channel 0, vertical), 2 (010) for the second component (channel 1, N/S) and 4 (100) for the third component (channel 2, E/W). So, for example, to enable triggering on all three components:

001+010+100 = 111 = 7

The command is:

7 triggers

This returns the configuration report:

Triggering on Data from:
Tap#2 20s/s 70 = Chans 4 5 6
Tap#2 20 s/s BandPass: 2.0->9.0Hz

(Note: Channels 4, 5 and 6 correspond to the bandpassed versions of data on Channels 0, 1 and 2)

The trigger operating mode can be disabled simply by sending the command:

0 triggers

DEFINING CHANNELS FOR OUTPUT ON TRIGGER

When a trigger is declared, the channels to be output are defined using the **TRIGGERED** command. This takes 2 arguments, the tap number (0-3) and the components (an integer defined from the bit values as for **TRIGGERS** defined above). For example:

0 7 triggered

will cause all three components to be output at 200 s/s on triggering. The configuration report will be:

Output Triggered Data from:
Tap#0 200s/s 07 = Chans 0 1 2

5.8 ABSOLUTE LEVEL TRIGGER

The Level trigger uses the same filters as the STA/LTA algorithm. It can be configured in the Configuration Setup area of SCREAM, or via the terminal.

To select channels for output use

tap# bit-pattern triggered (see the sta/lta section)

where tap# is 0 - 3 and bit-pattern is 0 - 7 e.g. 0 7 triggred is all 3 components from tap#0 (200 sps).

To select the triggering source, use

tap# bit-pattern gtriggers

e.g.1 1 gtriggers specifies z component of tap#1 as the signal to monitor

To set triggering levels, use

###,### micro-g

where ###,### are 1 or 3 32-bit parameters e.g. 123,000 or 345,600 (micro-g)

Once the triggered and gtriggers have been set, the levels can be changed on-the-fly without rebooting.

6.0 GPS-3

6.1 DESCRIPTION

The GPS-3 Receiver Unit comprises an antenna, the GPS receiver electronics, wide range input isolated dc power supply and output line drivers.

The antenna and all the associated electronics above, are all combined and housed inside a specially designed enclosure. The enclosure is sealed with 'O' rings and manufactured from a hard rigid resin. It is a stand-alone unit that is powered from the digitiser it is connected to.

GPS data (position, date/time and status) is output in NMEA format at 4800 baud once per second. Time synchronisation pulse (100 ms duration) is output at 1 pps. Both outputs use RS232 (or RS422 option) line drivers allowing use of long cables (up to 100 metres or more).

For further information on time stamping and clock synchronization, see the digitizer and status sections of this User's Guide.

7.0 COMMUNICATIONS - UPS BOX DESCRIPTION

7.1 UNINTERUPTIBLE POWER SUPPLY

The Communications-UPS Box includes an uninterruptible power supply which automatically provides up to 4 hours of backup operation for the communications device (server or modem) and the CMG-5TD with GPS. The Communications-UPS Box operates on 100-240 VAC, 50-60 Hz mains power supply.

7.2 SERIAL SERVER

The server used is the Lantronix MSS-100. The Serial Server box has a switch on the outside that allows the user to select the box's output method: serial data on the serial port, or TCP/IP data on the ethernet port. The server is shipped pre-configured, with the IP address shown on the box and a baud rate of 57600. For further server configuration information, refer to the Lantronix MSS-100 user manual.

7.3 SERIAL MODEM

The modem used is the US Robotics 56K Courier. The Serial Modem box has a switch on the outside that allows the user to select the box's output method: serial data on the serial port, or telephone data on the modem port. The modem is shipped pre-configured, with a baud rate of 57600. For further modem configuration information, refer to the US Robotics Courier user manual.

8.0 TYPICAL TEST DATA

Calibration data and poles and zeros information can be requested for any Guralp systems instrument by sending an email message to caldoc@guralp.com. In the subject of the message, enter the instrument serial number. You will receive a WORD document by automatic return email.

8.1 SENSOR CALIBRATION SHEET AND FREQUENCY RESPONSE PLOTS

1. CALIBRATION SHEET

* The data provided in the calibration sheet are the measured acceleration responsivities over the flat portion of the sensor frequency response. The acceleration responses are given in units of Volts/metre/second * second ($V/m/s^2$).

The sensor acceleration outputs are differential (push-pull or balanced output) and it is required that a factor of * 2 must be used when the sensor outputs are interfaced to a recording system with a differential input. For example, in the calibration sheet, the acceleration responsivity may be given as 2 * 50 $V/m/s^2$ which includes the factor * 2.

Do not ground any of the differential outputs. When interfaced to a single input recording system use the signal ground as the return line.

* Works Order Number is the number used at Güralp Systems Limited to file sensor manufacturing details.

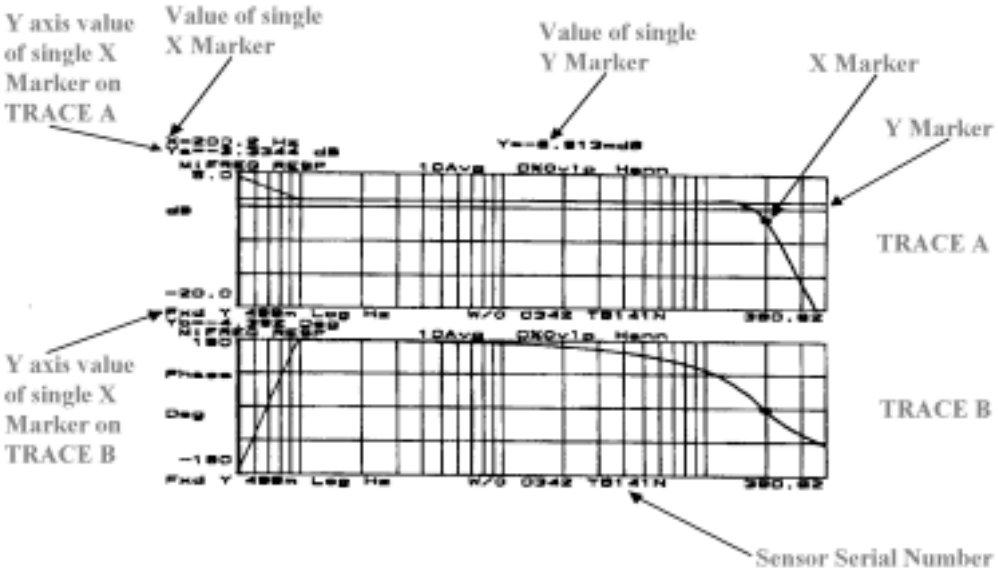
2. FREQUENCY RESPONSE

The frequency response of each component is provided as amplitude and phase plots.

When testing the instrument, to confirm that it meets its design specification, it is most convenient in any one test to concentrate the range of frequencies over about 3 decades (i.e. 1000:1) of excitation frequencies. Consequently the normalized frequency plots of each component are provided. In each plot, the frequency cut-off value (often quoted as -3dB or halfpower points) are marked. The frequency responses are normalized (unity gain) in order to show the corner frequencies.

Frequency response tests are always performed on every sensor produced at Güralp Systems Limited and records are archived for future reference.

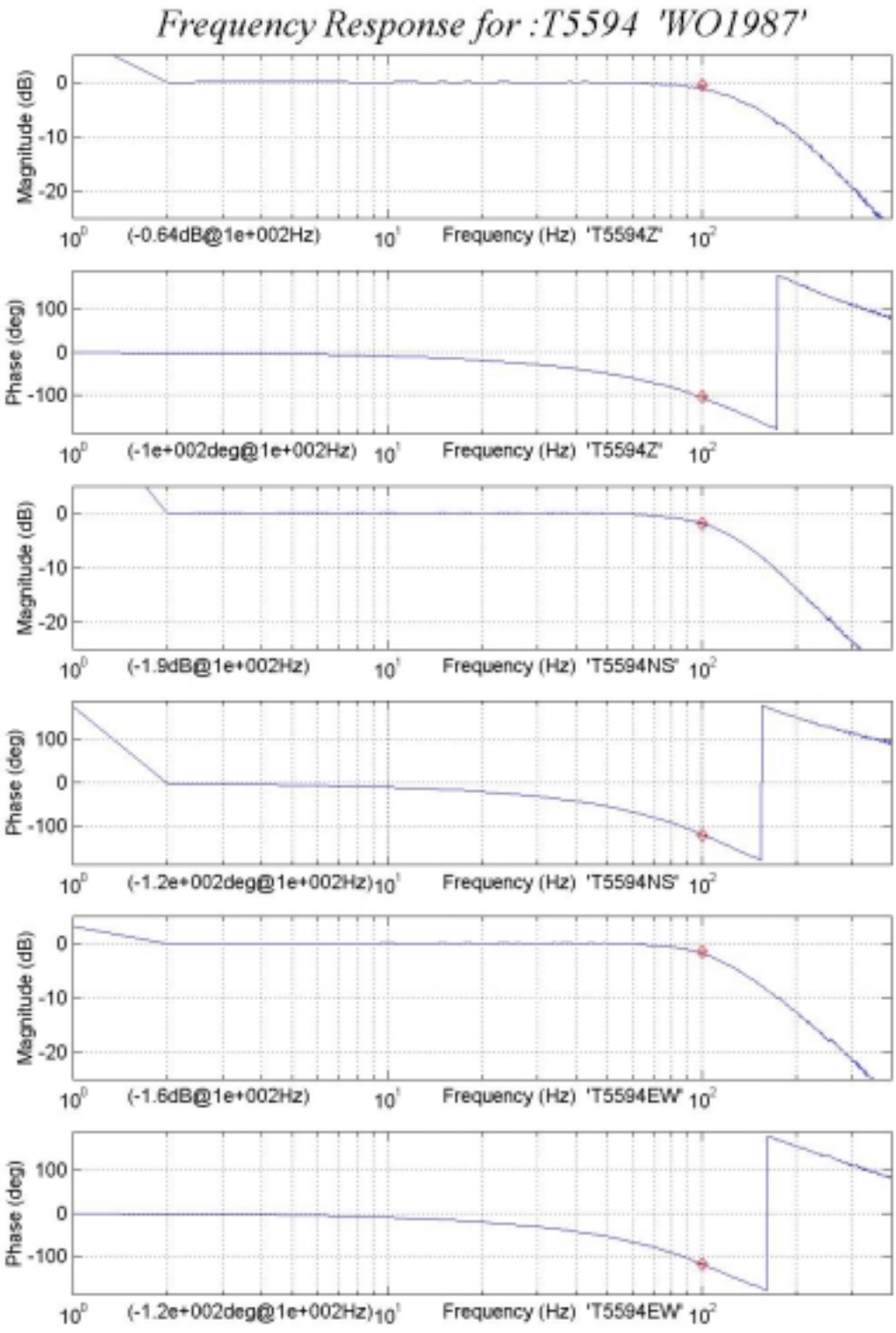
There are two types of frequency plot representations. These are explained in the following frequency amplitude and phase plots.


Y axis value of single X Marker on TRACE A
Value of single X Marker
Value of single Y Marker
X Marker
Y Marker
TRACE A
Y axis value of single X Marker on TRACE B
TRACE B
Sensor Serial Number

Frequency response from 488 milliHz to 390.62 Hz

TRACE A:- Y axis in dB.

TRACE B:- Y axis in degrees.


Frequency Response for :T5594 'WO1987'
Magnitude (dB)
(-0.64dB@1e+002Hz)
Frequency (Hz) 'T5594Z'
Phase (deg)
(-1e+002deg@1e+002Hz)
Frequency (Hz) 'T5594Z'
Magnitude (dB)
(-1.9dB@1e+002Hz)
Frequency (Hz) 'T5594NS'
Phase (deg)
(-1.2e+002deg@1e+002Hz)
Frequency (Hz) 'T5594NS'
Magnitude (dB)
(-1.6dB@1e+002Hz)
Frequency (Hz) 'T5594EW'
Phase (deg)
(-1.2e+002deg@1e+002Hz)
Frequency (Hz) 'T5594EW'
Low Gain Acceleration Output
25-May-2002

3. SENSOR TRANSFER FUNCTION

It is convenient for most users of seismometers to consider the sensors as 'black-boxes'. Thus the details of the internal mechanics and electronics need not be known, but only the overall effect of the instrument in producing a usable output signal V from the desired input variable of x is required. The generic form of such a transfer function (in terms of Laplace variable, s) is given as:

where:

$$\frac{V}{x}(s) = G * A * H(s)$$

G: Is the acceleration output sensitivity (gain constant) of the instrument relating to the actual output to the desired input over the flat portion of the frequency response. Output sensitivity is supplied in the calibration sheet.

A: Is a constant which is evaluated to make the magnitude of A * H(s) unity, with no dimensions over the flat portion of the frequency response. In practice it is possible to design a system transfer function with a very wide range of flat frequency response. For convenience, the normalising constant A, is calculated at a normalising frequency value fm = 1 Hz, with s = j fm, where j = √-1. The value of A is given in the poles and zeros table.

H(s): The transfer function of the sensor can be expressed in factored form.

$$H(s) = \frac{\sum_{n=1}^{N}(s - z_n)}{\sum_{m=1}^{M}(s - p_m)}$$

z_n : are the roots of the numerator polynomial, giving the zeros of the transfer function,

p_m : are the roots of the denominator polynomial giving the poles of the transfer function. See: poles and zero table.

8.2 POLES AND ZEROS TABLE

The CMG-5TD Poles and Zeros are given on the Guralp Systems web site (www.guralp.com)

8.3 DIGITIZER CALIBRATION SHEET

1. WORKS ORDER NUMBER: The Works Order Number is the number used at Güralp Systems Limited to file sensor manufacture details.

2. SYSTEM ID: This number (can be alphanumeric) can be used by the customer to identify the name of a network. Normally it is set to be the Works Order Number. The customer can change the System ID (a 6 character space is available).

3. UNIT ID: Specified the name of the data stream. Unit ID is designed to be used as a station identifier within a network. It is normally set to be the serial number of the station. When the Unit ID is changed the last two characters are used by the DM to identify the component and the sample rate associated with that component. Only 4 characters are available to the user as the last two characters are overwritten by the DM.

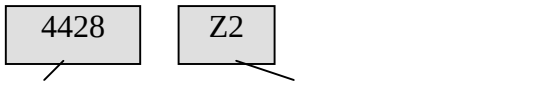
4. OUTPUT DATA FORMAT: GCF stands for Güralp Compressed Format.

5. BAUD RATE This is the baud rate set at the factory. The baud rate can be changed by the customer.

6. ACCELERATION CHANNELS: The sensitivity of each digitizer channel in units of Volts/bit and combination of each sensor digitizer channel in units of m/s^2/bit is given.

The calibration of each sensor acceleration output is also given separately in the sensor calibration sheet in units of $V/m/s^2$.

The stream ID specifies the component and the tap used from the DSP which provides the sample rate. For example.



7. ENVIRONMENTAL CHANNELS: The temperature is given in units of Kelvin. For example, 24000 bit will correspond to 24000 x 0.0124 Kelvin or 297 Kelvin.

The relative humidity (RH) is given as % of humidity. For example, 40% relative humidity will give a count rate of (40-30)/0.0023 counts (4347 counts).

9.0 CONNECTOR PINOUTS

9.1 CMG-5TD

Analog Port

NOTE: FOR DC OFFSET ADJUST, USE PINS:

M-L (VERTICAL)
C-D (NORTH/SOUTH)
U-K (EAST/WEST)

DESCRIPTION	PT0-06-14-19S
+ 12 V	F*
0 V	G *
SIGNAL GROUND	T
OPEN/CLOSED LOOP	J*
CAL ENABLE	S*
CAL SIGNAL	E*
+H ACC VERTICAL	P
-H ACC VERTICAL	N
+L ACC VERTICAL	M
-L ACC VERTICAL	L
+H ACC N/S	A
-H ACC N/S	B
+L ACC N/S	C
-L ACC N/S	D
+H ACC E/W	R
-H ACC E/W	V
+L ACC E/W	U
-L ACC E/W	K

Power/Data Port

FUNCTION	CONNECTOR 02E-12-10P
+ Vin (Digitizer and Sensor Power 10 to 36 Volts)	B
0 Vin (Digitizer and Sensor Power 0 Volts)	A
COM1 Tx (Transmit data)	K
COM1 GND	G
COM1 Rx (Receive Command etc.)	J
COM1 CTS	C
COM1 RTS	D

All the COM port outputs are optically isolated.

GPS Port

FUNCTION	CONNECTOR 02E-12-10P
Terminal Tx (Transmit to the terminal)	E
Terminal Rx (Receive from terminal)	F
+V Supply to GPS from sensor	B
0V Supply to GPS	A
COM2 Tx (Transmit to GPS)	J
COM2 GROUND	G
COM2 Rx (Receive data from GPS)	K
1Hz Reference, RS232 Level Isolated	C
Terminal GND	H

Terminal connections are not isolated. COM2 connections to GPS are all optically isolated.

9.2 GPS-3

GPS Port

FUNCTION	CONNECTOR 02E-12-10P
Terminal Tx (Transmit to the terminal)	E
Terminal Rx (Receive from terminal)	F
+V Supply to GPS from sensor	B
0V Supply to GPS	A
COM2 Tx (Transmit to GPS)	J
COM2 GROUND	G
COM2 Rx (Receive data from GPS)	K
1Hz Reference, RS232 Level Isolated	C
Terminal GND	H

9.3 COMMUNICATIONS-UPS BOX

CMG-5TD Port

10-way mil-spec socket:

Pin A 0V
Pin B +V
Pin C CTS
Pin D RTS
Pin G Isolated Ground
Pin J RX
Pin K TX

Serial Port (Server and Modem versions)

9-way D-type socket:

Pin 2 Tx
Pin 3 Rx
Pin 5 Ground

Ethernet Port (Serial Server version)

Standard RJ-45.

Telephone Port (Serial Modem version)

Standard telco.

10.0 SPECIFICATIONS

10.1 TECHNICAL SPECIFICATIONS

See the current specification sheet for the CMG-5TD.